University of Michigan
Gen. Lib.
Ann Arbor, Mich.
6-56

JOURNAL

VOLUME 12, NUMBER 9 • SEPTEMBER, 1956

SEP 14 1956
EAST ENGINEERING LIBRARY

Manufacturing Flexible Molds

(Story on page 56)

PUBLISHED BY THE SOCIETY OF PLASTICS ENGINEERS, INC.

Forticel Cabinet molded for Zenith by Plastic Molded Products Company, Chicago

These are the balanced properties that are giving Forticel its reputation as a "designer's plastic."

TYPICAL PHYSICAL PROPERTIES OF FORTICEL

Flow temperature:		
(°C.) (A.S.T.M.)	D569-48	167—178
Specific gravity	D176-42T	1.18—1.21
Tensile properties:		
Yield (p.s.i.)	D638-52T	3380—5020
Break (p.s.i.)	D638-52T	3470—5240
Elongation (%)	D638-52T	56—66
Flexural properties:		
Flexural strength (p.s.i. at break)	D790-49T	6400—8500
Flexural modulus (10^5 p.s.i.)	D790-49T	0.23—0.30
Rockwell hardness:		
(R scale)	D785-51	62—94
Izod impact:		
(ft. lb./in. notch)	D256-43T	2.7—11.0
Heat distortion:		
(°C.)	D648-45T	59—70
Water absorption:		
% sol. lost	D570-42	0.00—0.08
% moisture gain	D570-42	1.5—1.8
% water absorption	D570-42	1.6—1.8

ZENITH *selects* FORTICEL

new Celanese propionate thermoplastic for its all-transistor portable

The heart of the new Zenith 800 is a remarkable 100% transistor circuit that delivers full room power, tone-true reception.

But what first attracts the eye is its satin-smooth, plastic cabinet—molded of the new Celanese thermoplastic Forticel.

Forticel was created and engineered for just such demanding applications . . . places where beauty and precision are twin specifications . . . where Forticel's qualities of moldability, superb surface finish, high impact strength, form retention and freedom from objectionable odor can contribute to ready consumer approval as well as manufacturing efficiencies.

We urge you to inspect the new Zenith 800 at your favorite radio shop, and see one of the most skillfully engineered circuits in Zenith history . . . and one of the most carefully engineered thermoplastics in service today. You will understand why Forticel has been welcomed by the molder and designer, and why it is being specified for an increasing number of famous name products.

Send for Product Bulletin NP-16. Use coupon below.

Celanese Corporation of America, Plastics Division
Dept. 170-1, 290 Ferry Street, Newark 5, N. J.

Send me New Product Bulletin NP-16 on Forticel Plastic.

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

Celanese plastics

Celanese® Forticel®

U.S.I. POLYETHYLENE PROCESSING TIPS

Vol. 1, No. 5

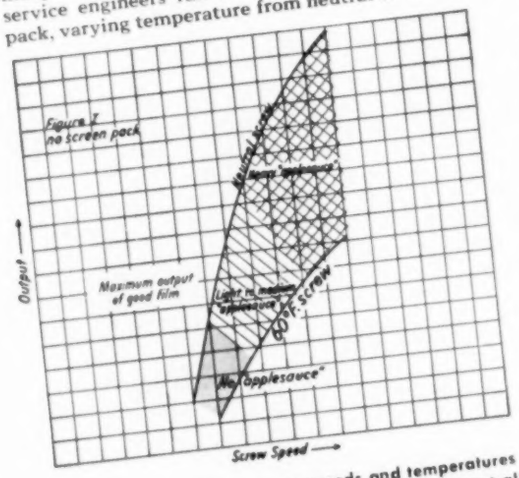
IMPROVE FILM APPEARANCE

If operating conditions are not quite right when polyethylene film is being extruded, the result is sometimes a pebbled, wavy structure which looks like applesauce. This "applesauce structure" is bad for two reasons. It not only gives the film a poor appearance, but also results in poor tear strength and lower impact resistance.

The problem: how to eliminate "applesauce structure" and still get maximum output. The solution: run a neutral screw (no cooling) at high speed, and use a heavy screen pack. The effects of these variables were studied in tests run with a $2\frac{1}{2}$" electrically heated extruder having a 13 to 1 L/D ratio.

Neutral Screw Gives Best Results

To determine the effects of screw temperature independent of screen pack, U.S.I.'s technical service engineers ran a series of tests with no pack, varying temperature from neutral to 60° F.

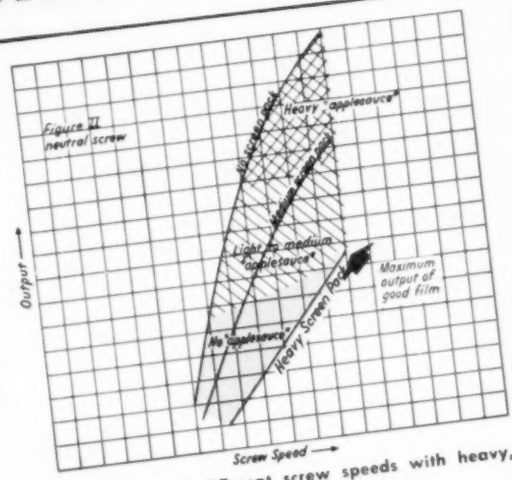


Film output at various screw speeds and temperatures with no screen pack. Only the two curves for neutral and 60° F screws are indicated, although several runs were made in between.

As you can see from Figure I, "applesauce structure" is heavy when output and speed are high, gets lighter and finally disappears as screw speed and consequently output are reduced. It is evident, however, that you get the highest output of satisfactory material when running with a neutral screw.

Heavy Screen Pack Increases "Applesauce"-Free Output

Having determined that a neutral screw gives best results, U.S.I. engineers then maintained that condition while studying the effects of various screen packs.



Film output at different screw speeds with heavy, medium and no pack, using neutral screw.

You can see from Figure II that the heaviest pack allows the greatest output of satisfactory film, although screw speed must be high to accomplish this.

By comparing Figures I and II it becomes evident that when you use a neutral screw, simultaneous use of a heavy pack can permit an output of quality film about 30% higher than that obtained with no screens, other conditions being the same.

U.S.I. Makes 3 Film-Grade Resins

These tests were run by U.S.I.'s technical service engineers, to help users of U.S.I. PETROTHENE® polyethylene resins make the best possible film for their customers. U.S.I. film-grade resins include:

PETROTHENE 110 and 210 – tailormade for blown and flat film extrusions. Degree of slip can be tailored to customer requirements.

PETROTHENE 213 – selected in specific cases for transparency, hand and high production rates.

U.S.I. Offers Technical Assistance

Because of space limitations, this has been only a brief discussion of the problem of getting the maximum output of film consistent with good appearance. However, U.S.I.'s technical service engineers have studied it in detail and will be glad to work with you on this or any other film extrusion problem you may encounter.

Send for PETROTHENE TIPS file folder.

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers Products Corporation
99 Park Avenue, New York 16, N. Y.
Branches in principal cities

SPE JOURNAL

Vol. 12 September, 1956 No. 9

Published monthly by

THE SOCIETY OF PLASTICS ENGINEERS, INC.

50 cents a copy $4.00 per year

Copyright by the Society of Plastics Engineers, Inc., 1956

JESSE H. DAY, Editor

Editorial Offices

Security Bank Building
Athens, Ohio

Executive and Business Offices

34 East Putnam Ave.
Greenwich, Conn.

Officers of the Society

Jerome Formo, President
Jules Lindau, III, Vice President
Peter W. Simmons, Secretary
Wayne Pribble, Treasurer
Jas. R. Davidson, Executive Sec'y.

Editorial Advisory Board

Gordon B. Thayer, Chairman
Russell B. Akin, Robert W. Barber, Edward F. Borro, Sr., William Croll, Russell M. Houghton, Allan A. Hutchings, John P. Lombardi, Jules Pinsky, Wayne Pribble, Walter E. Rahm, Frank W. Reinhart, Robert D. Sackett, Edward W. Vaill, Donald R. Williams.

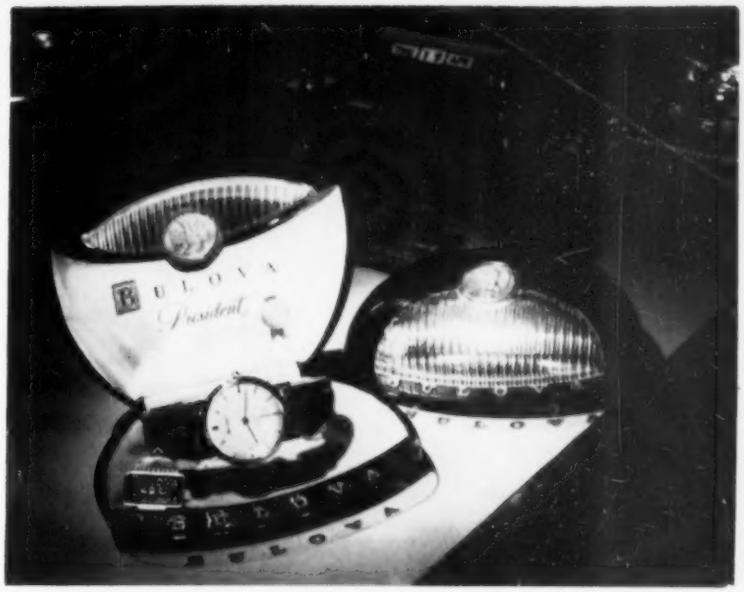
Advertising Representative

The Dougherty Co.,
515 Madison Ave.,
New York 22, New York

● All correspondence dealing with business matters, membership, advertising and the like should be addressed to the business offices listed above.

● All copy intended for publication in the SPE journal should be directed to the editorial offices. Copy for each issue should be received at Athens, Ohio, before the first of the month preceding publication. Neither The Society of Plastics Engineers nor the SPE Journal is responsible for the views expressed by individual contributors.

● Entered as second-class matter at the Post Office at Athens, Ohio.



Crystal Spotlight

This revolutionary new plastic display box is highlighting the Bulova Watch Company's new "President" series of watches. Designed of navy blue plastic, it features a highly-polished crystal clear plastic grill in the cover that captures light and focuses it on the watch in the box.

A radical departure from the traditional opaque watch box, this will undoubtedly have far-reaching implications in the whole plastics and packaging display field.

INDEX

ARTICLES

Service Temperature Characteristics of Molded Acrylic Parts—J. J. Gouza and E. N. Robertson ... 19

Flow Behavior of Phenolics Under Molding Conditions—D. I. Marshall ... 25

New Fields for Plastics—J. O. Reinecke ... 34

Polysulfide Liquid Polymer and Modified Epoxy Resin Casting Compounds—A. J. Breslau and K. R. Cranker ... 36

The Importance of Engineering Talent —H. S. Ruekberg ... 43

FEATURES

Action by Your National Organization ... 47

Plastics Meetings & Programs ... 48

Industrial Literature ... 50

News of the Industry ... 51

The Injection Molderscope ... 52

Plastics Around the World ... 53

SPEaking of Extrusion ... 54

Frankly SPEaking ... 58

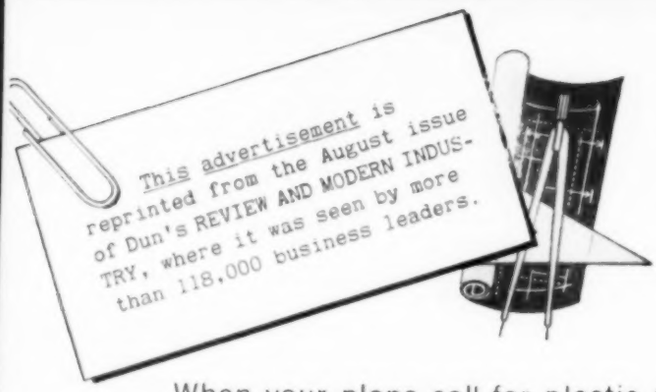
Book Reviews ... 56

Classified Ads ... 64

ADVERTISERS' INDEX 64

Craftsmen of the 20th Century

No. 18 of a series to introduce you to some of industry's outstanding plastics craftsmen


This advertisement is
reprinted from the August issue
of Dun's REVIEW AND MODERN INDUS-
TRY, where it was seen by more
than 118,000 business leaders.

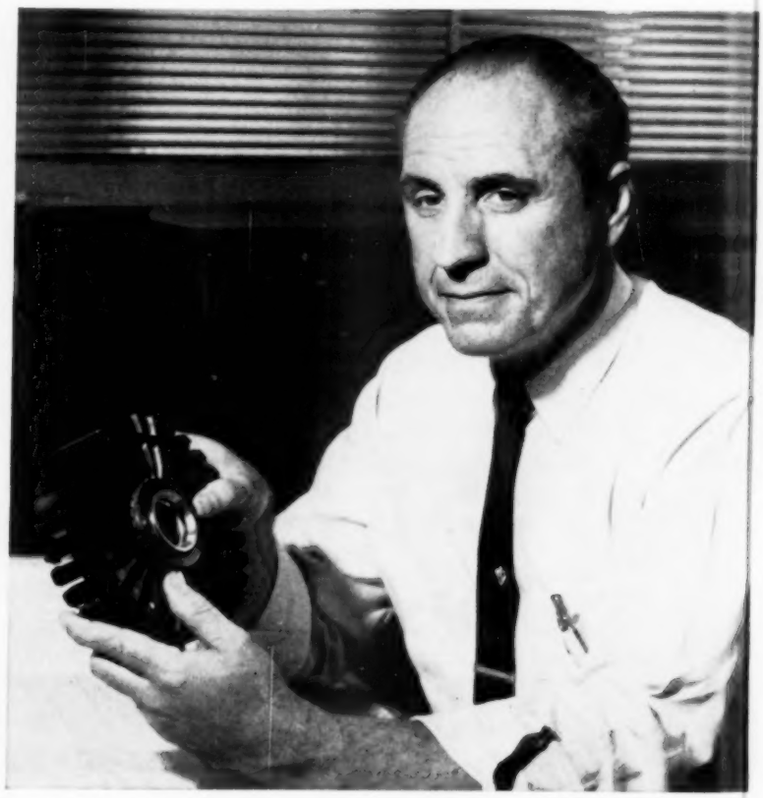
Where artisans once worked their creative magic in wood and glass and metals for the pleasure of a few, now their present day counterparts apply their skills to the field of plastics, and bring beauty and utility to millions.

Pictured below are two of the many specialists who contribute to the plastic products serving every home and every industry. Monsanto, a major producer of quality plastics materials, salutes these modern craftsmen who are helping to mold America's tomorrow.

When your plans call for plastic parts or products, consult an expert custom molder

Rudy Zoske, Northwest Plastics, Inc., St. Paul, Minn. They call Rudy Zoske "a customer's man on our payroll" because of the high standards he sets as head of quality control at Northwest. His department of 12 inspectors, employing many testing machines and gauges designed and built by themselves, rove through the departments, work directly on the press line, or conduct continuous dimension checks, through all 3 shifts. Mr. Zoske makes it a practice to keep in close contact with customers about their product specifications. He also confers with the tool designers on job requirements and supervises production from a quality standpoint.

A firm advocate of quality control, Mr. Zoske reports: "Strict examination of the appliance and electronic parts we manufacture, for warpage, dimensional change, impact strength, or whatever qualities are vital to the customer, has held plant rejects to a minimum. That's why customers appreciate the quality of our molding work."



C. Kenneth Swartz, Consolidated Molded Products Corp., Scranton, Pa. Since joining Consolidated in 1924, Ken Swartz has participated in the designing of over 5000 compression, injection, and vacuum-type molds. Now manager of the Development Division, he supervises the design of tools for the intricate, close tolerance gears, switch components, terminal boards, and dial-face moldings that are Consolidated's main products. "Creating a mold today is no overnight job," Mr. Swartz points out. "Not when a single tool may require as much as 200 man-hours of design time." Nevertheless, his 5 senior tool designers develop about 155 new tools every year, some valued up to $20,000.

Mr. Swartz has served on the Mold Design and Recommended Steels Committee of the Editorial Board of the Plastics Industry Engineering Handbook since 1953. In tool designing his firsts include basic patents for applying a crackle finish to a steel mold (1954) and a patent on molding hollow articles with a special core motion.

MONSANTO CHEMICAL COMPANY,
PLASTICS DIVISION, SPRINGFIELD 2, MASS.

MONSANTO

Resinox: Reg. U. S. Pat. Off.

RESINOX

PHENOLIC MOLDING COMPOUNDS

MAKING YOUR OWN DISPERSIONS?

YOUR BUSINESS IS PLASTICS

OUR BUSINESS IS COLOR DISPERSIONS

You may also be discovering some problems . . . color contamination, pigment agglomeration, costly clean-up time, excessive compounding time. But ADP can take all these problems right off your mind . . . because *our business* is color dispersions.

ADP Dispersions, produced by the world-famous Acheson process, are colloidal in nature . . . give you uniform shade and more "mileage" from your concentrate. With less concentrate, there's less compounding time, and therefore more "mileage" from your equipment, too.

The ADP colors you want are matched by modern scientific methods, and can always be precisely duplicated. Your product looks better, costs less.

ADP specialists, without obligation, will consult with you on an individual basis. *Their business* is color dispersions, and they know it thoroughly. They will be glad to help *your business*.

CONTROLLED* COLORS BY adp

ACHESON DISPERSED PIGMENTS CO.

MORRIS BUILDING, PHILADELPHIA 2, PA. • A UNIT OF ACHESON INDUSTRIES, INC.

West Coast Distributor: **B. E. Dougherty Co., Los Angeles 21, California**

In Europe: ACHESON COLLOIDS LTD., 18 Pall Mall, London, S.W.1 England

100th Anniversary

1891—SILICON CARBIDE
1895—SYNTHETIC GRAPHITE
1908—COLLOIDAL GRAPHITE

*Because ADP dispersions are colloidal in nature, with pigment particles of microscopic size.

HERE IT IS! THE *New* THOMAS

Automatic Injection Molding Machine

Revolutionary Electro-Hydraulic System Lowers Both Machine and Operating Costs

SPECIFICATIONS TYPE ND 30

- 1 oz. capacity
- 1,200 shots per hour—dry run
- 15 lb. per hour plasticizing capacity
- 9" x 10" mold space
- 6" stroke
- 14" daylight
- 15,000 psi injection pressure
- 30 tons maximum mold locking force
- 3 hp motor operates entire machine
- Fully automatic operation
- Motor and electrical controls by Westinghouse
- Wheelco instruments, Eagle timers
- 2,200 lb. gross weight
- 28" x 89" floor space
- Completely self-contained

The rugged new Thomas Automatic injection molding machine fills many vital needs. Its small size and low cost make it ideal for laboratory research work, college and trade training, market testing, mold testing and the economical production of small items. Because it is completely automatic, and features low pressure closing with safety drive, one operator can easily run a battery of these machines.

The basic difference between the new Thomas Automatic and others is the unique, new electro-hydraulic drive which uses power much more efficiently than conventional methods. It is completely self-contained, requires no auxiliary equipment and will mold nearly all thermoplastic materials including nylon.

WRITE *for brochure and complete information.*

THOMAS MACHINE DIVISION

NEWARK DIE COMPANY 22 Scott Street
Newark 2, N. J.

NEW DU PONT POLYETHYLENE FORMULATIONS

Alathon® 34 and 37

OFFER

- superior film transparency
- superior stiffness
- superior impermeability
- superior heat resistance

The addition of ALATHON 34 and ALATHON 37 to the family of Du Pont polyethylene resins enables users to take advantage of certain combinations of characteristics not previously available in any one polyethylene.

The density of both ALATHON 34 and 37 is between that of conventional polyethylenes and the new linear materials. Both ALATHON 34 and 37 have narrow distribution of molecular weights. But ALATHON 34 has a low melt index, while ALATHON 37 has a moderately high melt index. Thus, the advantages of high density are made available for end uses requiring different processing conditions.

Uses . . .

FILM . . . Film of ALATHON 34 is extremely transparent and sparkling. It has considerable stiffness and is thereby particularly adaptable to automatic packaging machinery. Film of ALATHON 34 has good impermeability to liquids, gases and greases.

BOTTLES . . . ALATHON 34 is an excellent resin for making flexible bottles. Its greater stiffness makes possible thinner wall sections and gives superior "snap-back" at equal wall thickness. The higher density of ALATHON 34 means greater impermeability to greases, essential oils and oxygen. The heat resistance of ALATHON 34 recommends its use for high-temperature applications such as encountered in sterilizing.

For certain bottle-making processes, ALATHON 37 offers most of the advantages of ALATHON 34 plus a lower melt viscosity, resulting in faster processing.

INJECTION MOLDING . . . Both ALATHON 34 and 37 have excellent molding properties. The high stiffnesses obtained permit ejection of parts from the mold at high temperatures, thereby shortening the molding cycle.

The gloss obtained by ALATHON 37 is outstanding. Molding can be made without a trace of "frosty" appearance. Mold shrinkage is low, resulting in low tendency to warp. Where resistance to environmental stress cracking is required, ALATHON 34 is preferable to ALATHON 37.

WIRE COATING . . . ALATHON 34, because of its high density, has superior high- and low-temperature properties. It has excellent abrasion resistance compared with other polyethylenes.

PAPER COATING . . . ALATHON 34 is particularly suited to paper-coating applications due to its superior grease resistance and low water-vapor transmission rate. Good adhesion to paper is obtained even at high speeds of application.

● *For further information on* ALATHON *34 and 37, write to E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 429, Du Pont Building, Wilmington 98, Delaware.*

IN CANADA: *Du Pont Company of Canada Limited, P. O. Box 660, Montreal, Quebec.*

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

How Koppers Chemicals can help you make better plastics

You will find that the high purity and exceptionally good color you can obtain in Koppers phthalic anhydride helps you to produce better water-white plasticizers for vinyl films. Koppers phthalic anhydride also is an important ingredient in polyester resins.

You will find several important uses in plastics for ***dbpc***® antioxidant, made by Koppers. It is a good color stabilizer for modified polystyrenes and for polyethylene. And it increases pot life of polyester premixes.

Derivatives of Koppers resorcinol give you effective light stabilization in cellulosics.

And don't forget Koppers styrene monomer—a good, high-quality starting point for polystyrene and polyester resins, and to extend polyester resins for lower-cost products without sacrificing quality.

There are many more where these came from. If you make plastics, or use them, send the coupon for complete information.

KOPPERS

KOPPERS CHEMICALS

Sales Offices: PITTSBURGH · NEW YORK · BOSTON · PHILADELPHIA · ATLANTA
CHICAGO · DETROIT · HOUSTON · LOS ANGELES · SAN FRANCISCO
In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ontario

Koppers Company, Inc.
Chemical Division, Dept. SPE-96
Pittsburgh 19, Pennsylvania

Please send information on Koppers Chemicals that are useful in the manufacture of the following plastics:

Name _____

Firm _____

Address _____

City & State _____

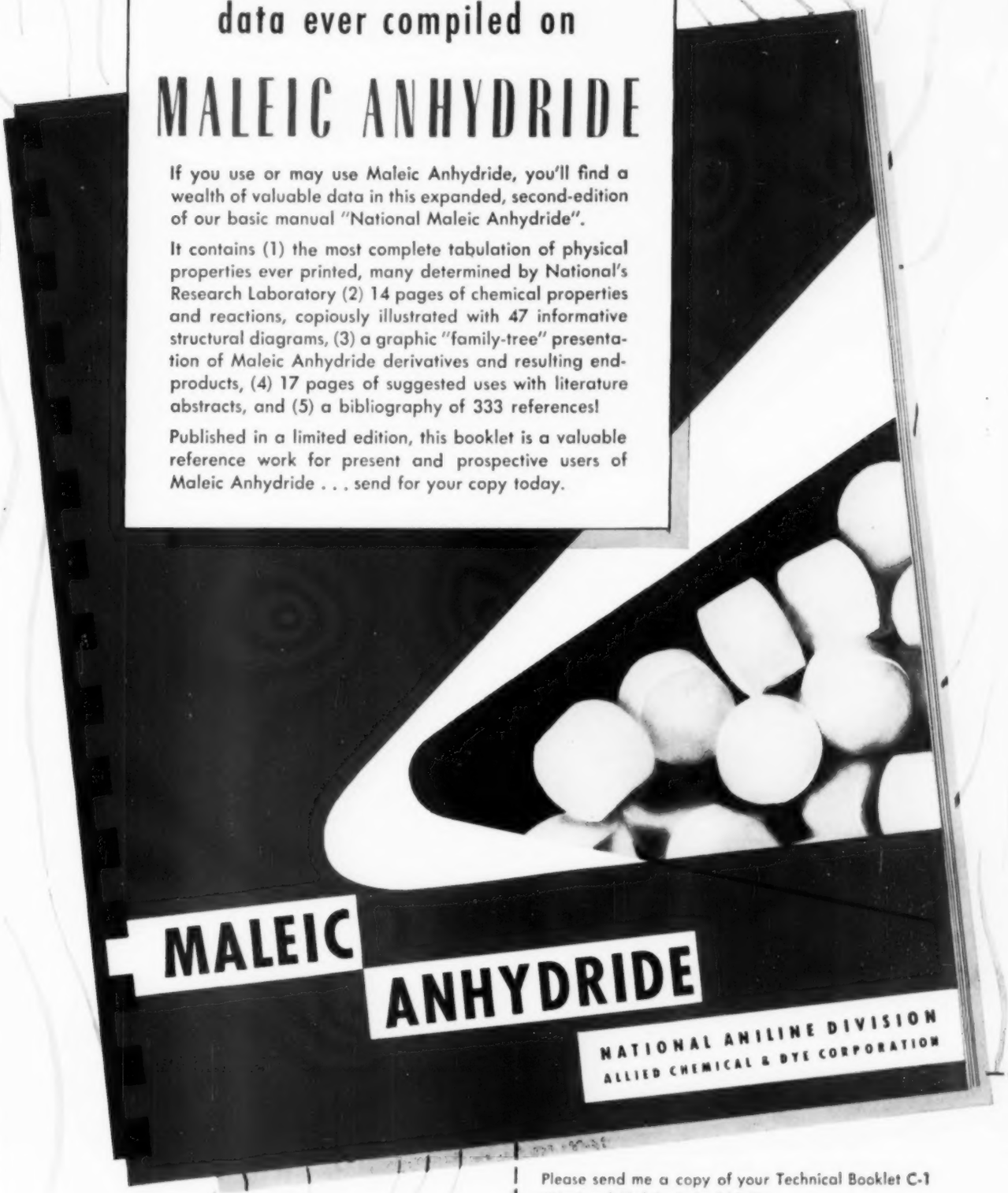
this 58-page booklet contains the most comprehensive data ever compiled on

MALEIC ANHYDRIDE

If you use or may use Maleic Anhydride, you'll find a wealth of valuable data in this expanded, second-edition of our basic manual "National Maleic Anhydride".

It contains (1) the most complete tabulation of physical properties ever printed, many determined by National's Research Laboratory (2) 14 pages of chemical properties and reactions, copiously illustrated with 47 informative structural diagrams, (3) a graphic "family-tree" presentation of Maleic Anhydride derivatives and resulting end-products, (4) 17 pages of suggested uses with literature abstracts, and (5) a bibliography of 333 references!

Published in a limited edition, this booklet is a valuable reference work for present and prospective users of Maleic Anhydride . . . send for your copy today.



Kindly fill out this coupon completely and attach to your letterhead.

Please send me a copy of your Technical Booklet C-1 "National Maleic Anhydride".

- ☐ We are using Maleic Anhydride
- ☐ We may use Maleic Anhydride
- ☐ I am personally interested

NAME: _____

POSITION: _____

COMPANY: _____

ADDRESS: _____

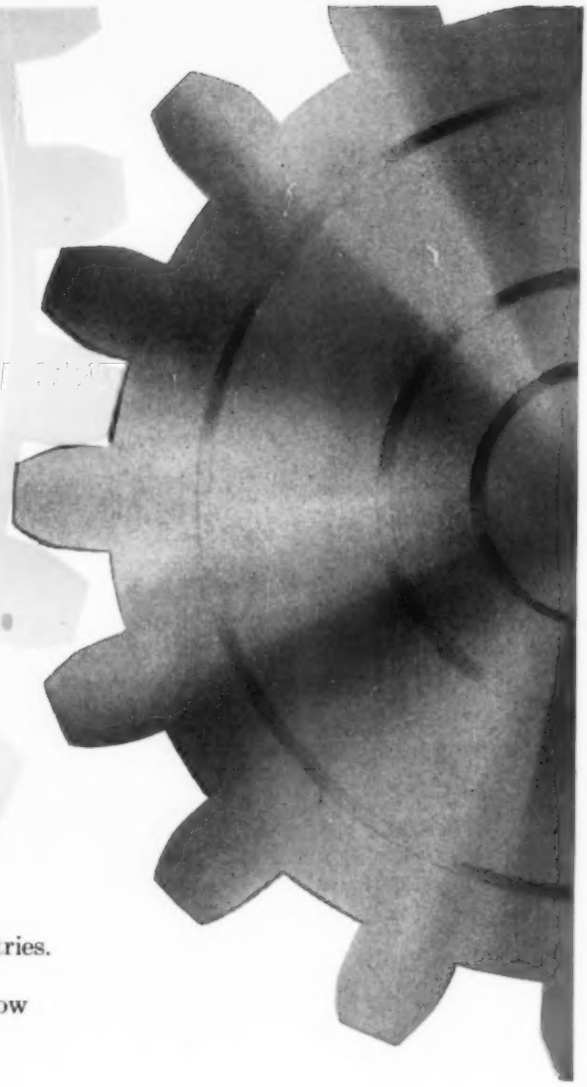
M-3

NATIONAL ANILINE DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N. Y.

Boston Providence Charlotte Chicago San Francisco Atlanta Portland, Ore. Greensboro Philadelphia Richmond Akron Los Angeles Columbus, Ga. New Orleans Chattanooga Toronto

KNOW-HOW

turns the wheels...



To the Escambia Bay Chemical organization have come men possessing many years of experience in the chemical and plastics industries. These men with their experience and know-how are backed by Escambia Bay's emphasis on continuing research, development, quality control, and product uniformity.

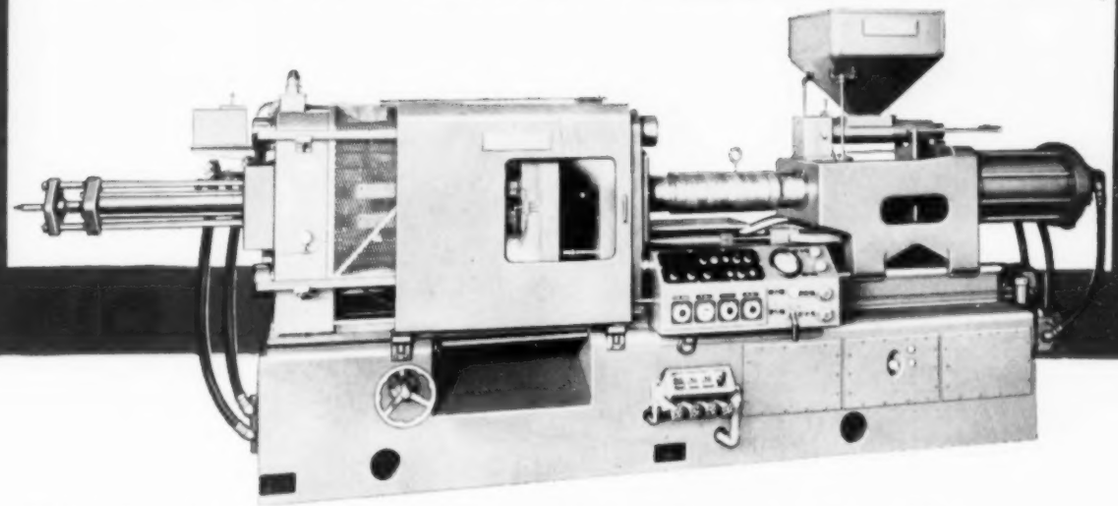
And with Escambia Bay coming on stream this fall with its Polyvinyl Chloride Resins Plant, this know-how will make its contribution to the continued progress of the plastics industry through intensive technical and customer service programs.

The first product—a general purpose, easy processing Polyvinyl Chloride Resin—will be in production soon for use in the calendering, extrusion and molding industries. Following this, Escambia Bay will produce a molecular weight range of straight PVC Resins including types for electrical and rigid applications.

ESCAMBIA BAY CHEMICAL
CORPORATION

261 MADISON AVENUE • NEW YORK 16, N.Y.

HERE'S ANOTHER NEW REED
...THE 275T–8/10 OZ. WITH
11 BIG NEW FEATURES



This is it — the latest addition to the complete line of REED injection molding machines. The new 275T—8/10 oz. has been designed to replace the well-known 10D-8 REED. It gives you higher speeds, increased plasticizing capacity, and far greater versatility. In the 275T, 11 big new features are combined with all the rugged dependability of its predecessor.

- **Higher Speed** – Dry cycle time cut to 8 seconds, with maximum cycles per hour increased 76%.
- **Greater Flexibility** – New adjustable die stroke, and 21% increase in plunger speeds. Three booster pumps permit you to vary plunger speeds as required.
- **Increased Plasticizing**– Larger REED-SPEED heater, with 120 lbs per hour capacity and 4-zone temperature control. New, single-nut mounting makes heater easier to remove.
- **Fully Automatic**–Newly-designed, low-pressure die closing unit is optional to protect molds during fully automatic operation.
- **Faster, Easier Set-Up** – Hydraulically-operated die space adjustment and plunger housing speed set-ups, eliminate nozzle breakage.
- **Safety Features** – Electric and hydraulic locks standard on safety door, with interlock system optional. New palm safety button provides automatic opening of press.
- **New Feed Assembly** – Simplified, easier to clean when changing materials.
- **Manifold Valves** – All valves manifolded to eliminate leakage and simplify maintenance.
- **Easy-To-See Controls** – New console control panel and separate control enclosure.
- **Vibration-Free** – Vibration-absorbing leveling mounts are standard equipment.
- **Higher Horsepower** – New 25 H.P. motor.

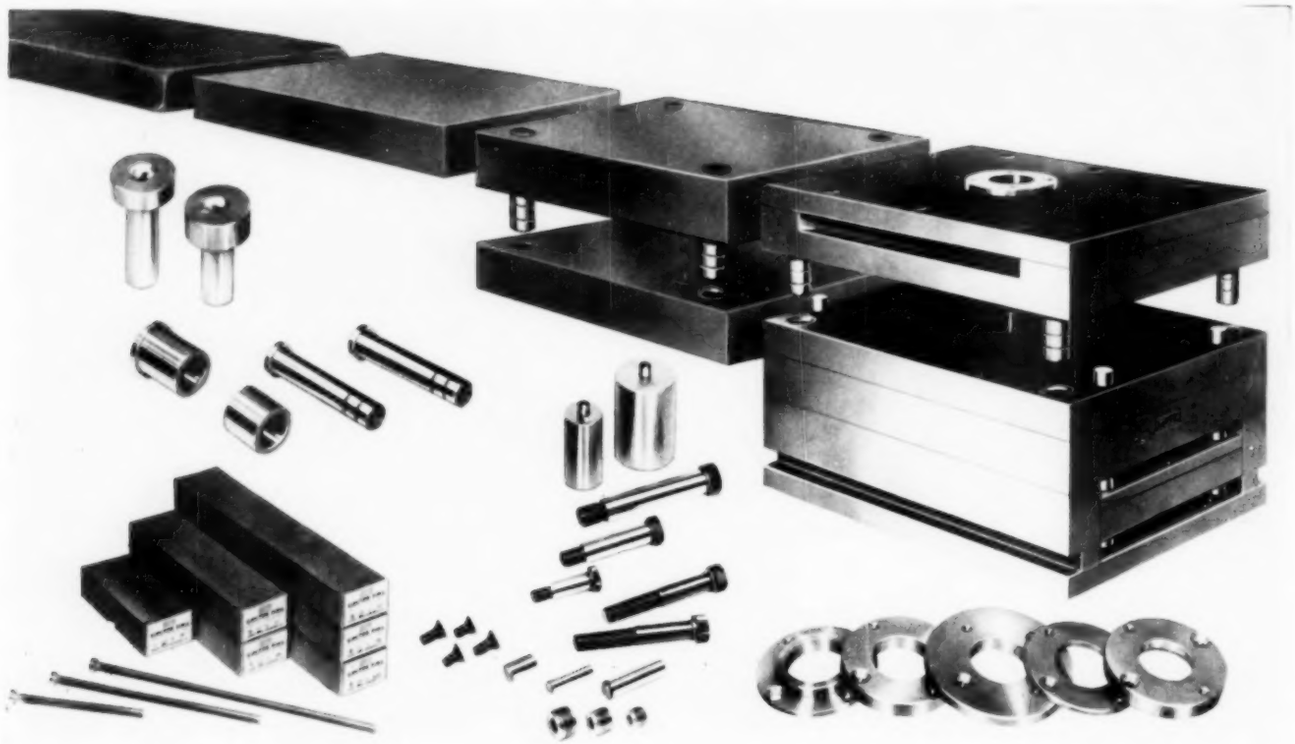
To get complete information on this new 275T–8/10 oz. addition to the line of 6 REED injection machines ranging from 4 oz. to 32 oz. capacities, or to find out about the revolutionary new REED *Autoflow* extruders, call your Reed-Prentice Sales Engineer today.

REED-PRENTICE

Affiliate of PACKAGE MACHINERY COMPANY

WORCESTER 4, MASS.

BRANCH OFFICES: NEW YORK • CLEVELAND • CHICAGO • BUFFALO • DAYTON • DETROIT • KANSAS CITY • LOS ANGELES REPRESENTATIVE: MINNEAPOLIS—CHAS. W. STONE CO.



PROGRESS THROUGH STANDARDS

. . . and how DME "helped"

The history of economy in modern business has been directly related to the history of Standardization. One of the major elements affecting the economic production of finished plastic parts is the high initial cost of the mold. A progressive step in reducing mold cost, without sacrificing the high quality required, has been successfully achieved through Standardization.

When D-M-E originated Standard Mold Bases and their component parts in 1942, it provided the answer to the rapidly growing demand for high quality molds that would maintain and promote the economic advantages of plastic parts.

Through large volume purchases of quality steel in standard sizes and specialized production facilities, D-M-E was able to produce and supply high quality Standard Mold Bases to mold makers and molders at such great savings in cost and time that the benefits of Standardization were quickly realized by the Industry.

Today D-M-E produces twenty-eight different sizes of Standard Mold Bases, from 9" x 8" to 23¾" x 35½", in either D-M-E No. 1 or No. 2 Steel, with a wide range of cavity plate thicknesses to satisfy the diversified demands required. In addition, over 2,000 finished component parts of the same high quality are available to provide additional savings in service as well as in the product.

Properly engineered Standardization puts the accent on Economy. When you "Specify D-M-E . . ." you get Quality, Service AND Economy!

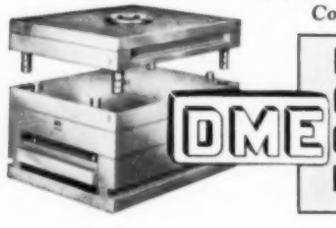
DETROIT MOLD ENGINEERING CO.

6686 E. McNICHOLS ROAD — DETROIT 12, MICHIGAN — TWinbrook 1-1300

Contact Your Nearest Branch FOR FASTER DELIVERIES!

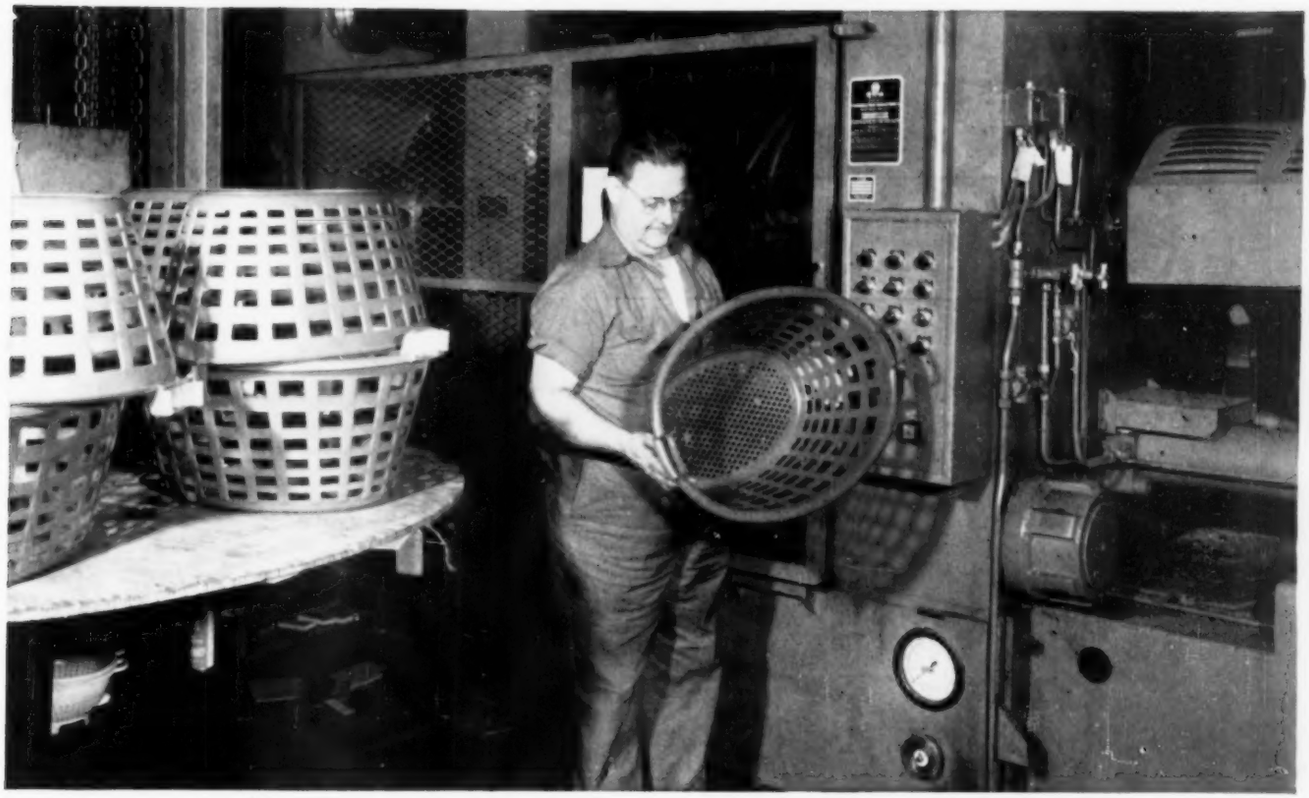
Specify **D-M-E** *for*

QUALITY . . .
SERVICE . . .
ECONOMY !

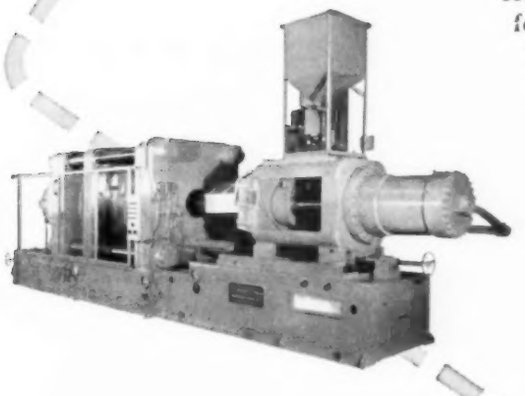


HILLSIDE, N. J. (NEAR NEWARK) 1217 CENTRAL AVE., ELIZABETH 3-5040
CHICAGO 51, ILLINOIS 5901 W. DIVISION STREET, COLUMBUS 1-7855
CLEVELAND 9, O. - D-M-E CORP. 502 BROOKPARK RD., SHADYSIDE 1-9202
LOS ANGELES 7, CAL. 3700 SOUTH MAIN STREET, ADAMS 3-8214

BASKET WEAVER—1956!



H-P-M 80 oz. molds Big Basket for the Monday morning market



Here's a real producer at work—every weekday!—for Columbus Plastic Products, Columbus, Ohio. This 80 oz. H-P-M Injection Molding Machine turns out polyethylene clothes baskets by the dozens every hour. An exceptional production rate is only one of H-P-M's big advantages. Here's where big molding areas and plenty of plasticizing capacity pay off. These big baskets are "shot" with a high-speed injection plunger that assures instant fill in complex molds. Get in the market—to stay—profitably—with H-P-M injection molding machines. H-P-M Bulletin 5601 tells you how.

Bring your production up to date with an H-P-M injection molder. 6 to 400 oz. capacities . . . 150 to 3000 tons clamping force.

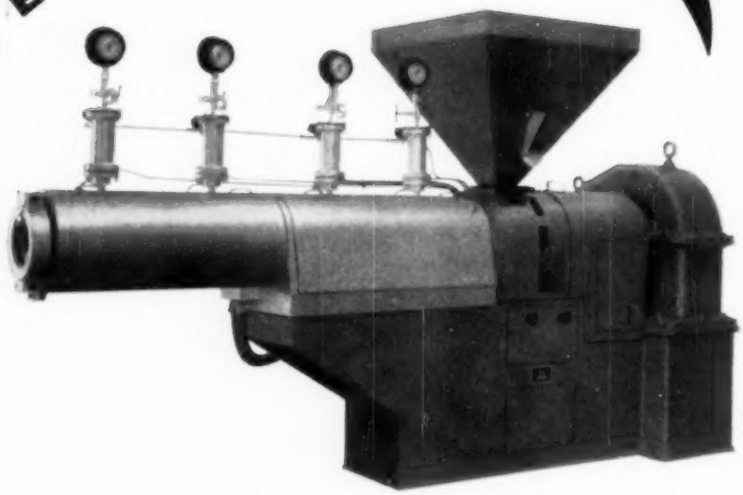
HPM

THE HYDRAULIC PRESS MFG. CO.

Mount Gilead, Ohio, U.S.A.

A DIVISION OF KOEHRING COMPANY

Egan EXTRUDERS



"WILLERT VAPOR PRESSURE COOLING"*

This *Egan* designed system automatically eliminates problems of overheating due to excessive frictional heat. It is completely automatic—No moving parts—No need for operator to determine whether cooling should be "on" or "off"

*Patent applied for

another Egan first

Standard *Egan* extruders for thermoplastics, in production use throughout the free world, have been designed for maximum flexibility and incorporate all the features important in extruder design.

Available with or without "Willert Vapor Pressure Cooling"* in all sizes from 2" to 8" • Screw lengths 16:1 or 20:1 • Hard corrosion resistant liners • Heavy duty thrust and radial bearings, force feed lubrication • Completely prewired temperature control cabinet • Screw speed tachometer • Precision ground screws Large feed hoppers with sight glass and cut-off slide Complete installations for film, sheet, pipe or shapes.

*Patent applied for

Write, or phone RAndolph 2-0200 today for complete information—no obligation.

FRANK W. EGAN & COMPANY, Somerville, New Jersey

Designers and Builders of Machinery for the Paper Converting and Plastics Industries

Cable Address: "EGANCO"— Somerville, Nier.

Representative: MEXICO, D. F. — M. H. Gottfried, Avenida 16 De Septiembre, No. 10.

Licensees: GREAT BRITAIN — Bone Bros. Ltd., Wembley, Middlesex. FRANCE — Achard-Picard, Remy & Cie, 36 Rue d'Enghien Xe, Paris. ITALY— Emanuel & Ing. Leo Campagnano, Via Borromei 1 8/7, Milano. GERMANY— ER-WE-PA, Erkrath, bei Dusseldorf.

Opportunity Knocking with a Triphammer Beat!

NATIONAL®

ADIPIC ACID

Volume production of Adipic Acid at our Hopewell, Va. plant opens the way to commercial development of new products based on adipic esters, particularly in plastics, plasticizers, rubber and lubrication oils. You are assured of uninterrupted supply based on our efficient, continuous process and fully-integrated production right back to basic raw materials within the Allied Chemical group.

National Adipic Acid is outstandingly good. It consistently analyzes 99.7% minimum purity, it is light in color and low in iron.

WRITE FOR TECHNICAL BULLETIN I-12

This 8-page bulletin gives complete physical and chemical properties; principal reactions of the carboxyl and alpha methylene groups; solubility curve, suggested uses and literature references. Working samples and quotation on request.

NATIONAL ANILINE DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N. Y.

Boston Providence Charlotte Chicago San Francisco Atlanta
Portland, Ore. Greensboro Philadelphia Richmond Akron
Los Angeles Columbus, Ga. New Orleans Chattanooga Toronto

Allied Chemical

DOW

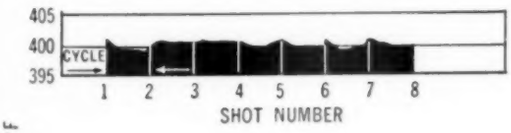
Now Dow Plastics
announces

NO. 8 GRANULATION

FOR NEW
HIGHS IN
MOLDING SPEED

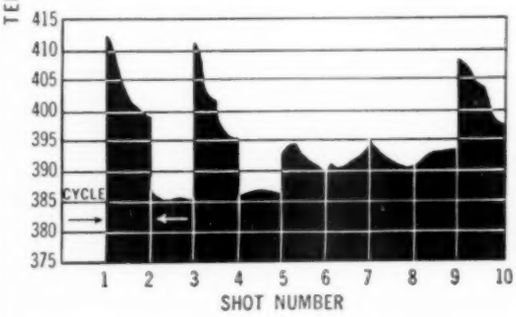
EFFECT OF
GRANULATION UNIFORMITY
ON PLASTIC TEMPERATURE

Mean Temperature 400°F
Uniform Granulation



TEMPERATURE, °F

Mean Temperature 400°F
Non Uniform Granulation



Advantages of easy flow greatly increased . . . available now in STYRON 689

New No. 8 granulation offers the injection molding industry advantages never before possible. The benefits range from faster molding to absolute optimum for heat absorption and increased plasticizing rate—including factors that open new possibilities for improved designs and upgraded fabrication.

The uniform size and shape of No. 8 granulation are the result of leadership in research coupled with far-reaching developments in production equipment. The exceptional uniformity will help you improve present injection molding methods and apply plastics to new uses.

Characteristics of Dow No. 8 Granulation:

.080 X .080 pellet size. Uniform screen analysis for maximum moldability assistance. Faster and more uniform heat absorption in cylinder—5% to 20% greater lbs. per hr. throughput. Freedom from silver streaking. Reliable volumetric and weigh feeding. Absence of fines. More uniform color distribution.

No. 8 Granulation Styron 689 . . .

. . . meets special requirements for molding thin sections, deep draws, and parts demanding accurate dimensional control. It is proved excellent for high-speed automatic molding and large area parts. Other Styron® formulations, as yet not available in No. 8 granulation, offer you a total of eleven different compounds. When you call Dow, you know you will find the right formulation for every molding need.

For further information, see your Dow man. Or write: THE DOW CHEMICAL COMPANY, Midland, Michigan—Plastics Sales Department PL 428D.

you can depend on DOW PLASTICS DOW

Service Temperature Characteristics

of Molded Acrylic Parts

By J. J. Gouza and E. N. Robertson

Rohm & Haas Company
Bristol, Penna.

THE USEFUL LIFE of a molded plastic part is frequently determined by the temperatures and stresses to which it has been subjected. This paper is concerned with the change with temperature of the characteristics of two commercial grades of acrylic injection molding materials. The pertinent characteristics which change with temperature are those which are ascribable to the material itself and those resulting from the method of molding the material. The former are readily measurable with standard testing techniques. Data from such tests will be presented for both materials. A limited study has been made of the effect of variations of the molding technique on the characteristics of a typical part molded from both of these grades of molding powder. The data and observations are being presented with the view of aiding the part design engineer in a logical choice of material and specification of the molding conditions.

Temperature Characteristics of the Materials

Standard test disc, bar and tensile specimens were molded from acrylic powders conforming to A.S.T.M. Materials Specification D788-48T, Grades 6 and 8 (Reference 1). These specimens were made in a 12-ounce Watson-Stillman injection molding machine using conditions which have been proven over a period of years to produce the best specimens for A.S.T.M.-type tests for properties. The machine was adjusted to the proper conditions for the grade of powder and thermally stabilized before any moldings were retained for test purposes. All moldings were cooled in still, room temperature air immediately after removal from the machine. They were subsequently heated for 48 hours at 50°C (122°F) and then placed in a desiccator at 23°C (73°F) over phosphorous pentoxide for 16 hours prior to testing. Those specimens tested at elevated temperatures were further heated for 1 hour at the test temperature immediately before testing.

The heat distortion temperature defined in A.S.T.M. Method D648-45T (2) is frequently used to distinguish between materials. The effect of numerous variables in this test have been recognized and described (3). Under the conditions employed in our laboratory, the heat distortion temperature of the molded bars was measured as:

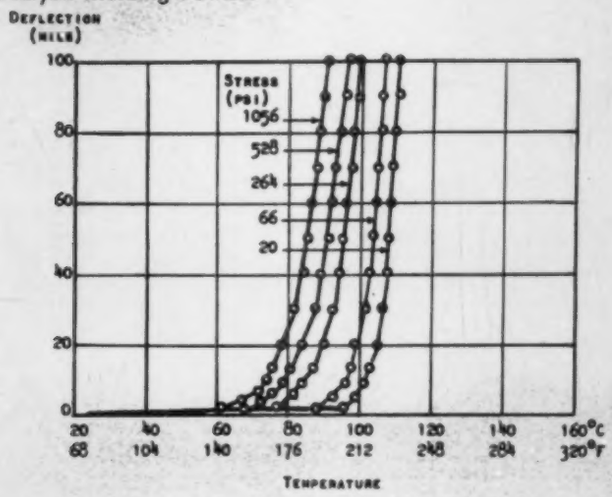
Grade 8 — 85°C (185°F)
Grade 6 — 77°C (171°F)

By using several different constant loads in this test, data are obtained which can be interpreted to give predictions of some of the high temperature characteristics of these materials.

Data from such tests are plotted as flexural deformation versus temperature in Figure 1 and Figure 2 for Grade 8 and Grade 6 material, respectively. The 10-mil deformation temperatures from these data are plotted versus applied stress as shown in Figure 3. The dimensional stability of the materials under short-time load can be approximately predicted by projecting the higher stress portion of the curves to zero stress (3). Such an extrapolation combines a measure of the softening temperatures of the materials with a measure of the change of apparent

FIGURE 1

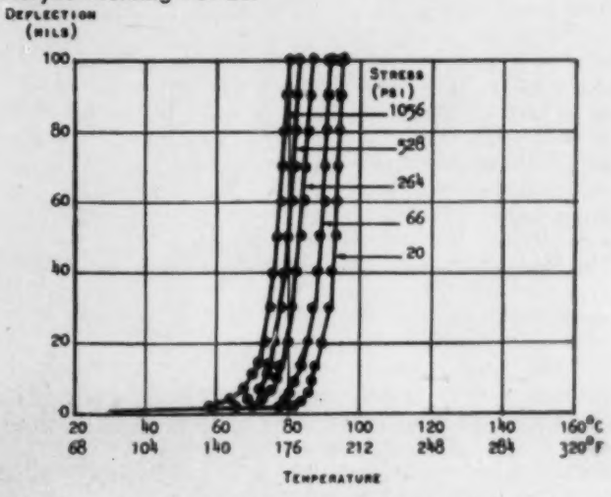
Flexural Deformation Versus Temperature of Grade 8 Acrylic Molding Powder



(Tested in the manner of ASTM D648-45T at 2°C/Minute and various stresses)

FIGURE 2

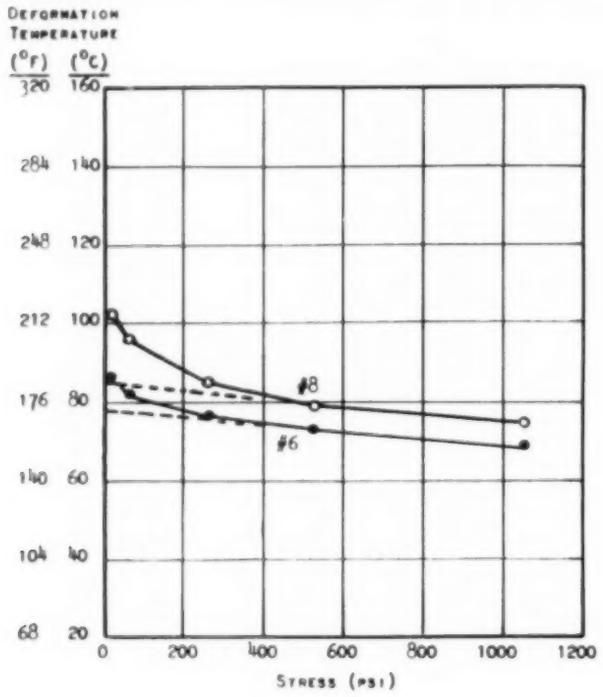
Flexural Deformation Versus Temperature of Grade 6 Acrylic Molding Powder



(Tested in the manner of ASTM D648-45T at 2°C/Minute and various stresses)

FIGURE 3

Flexural Deformation Temperatures Versus Stress of Grades 6 and 8 Acrylic Molding Powder at a 10 mil Deflection



softening temperatures with moderately high values of stress.

In many designs, resistance to moderately high flexural or tensile stress is important. Figures 4 and 5 show the flexural and tensile modulus of elasticity versus temperature for Grades 8 and 6 material. Figures 6 and 7 show the maximum flexural and tensile strength versus temperature for these materials. These data were determined in accordance with A.S.T.M. methods (4, 5). Over the temperature range shown there is an approximate straight line relation between strength and temperature. These lines intersect the zero strength axis at the 100 mil, 20 psi flexural deformation temperature shown in Figures 1 and 2 for the respective material. (A similar relation has been noted for cast acrylic materials in References 3 and 6.) Therefore, for these types of polymers, it is possible to predict with fair accuracy the strength versus temperature curve by a room temperature strength measurement and a flexural deformation temperature measurement.

There are other factors to be considered in the choice of a material and the design of a part for high temperature service. Among these are (1) impact strength, (2) coefficient of thermal expansion, and (3) water sorption. The Izod impact strength of the two grades of acrylic is approximately the same and varies little over the temperature range studied. These data, obtained in accordance with Reference 7, are shown in Figure 8.

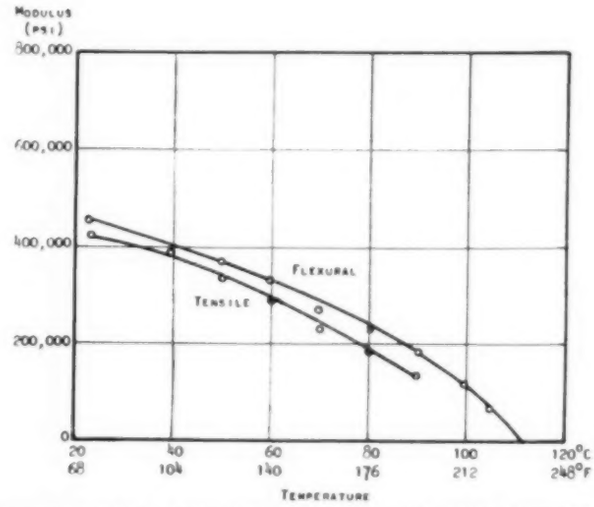
The coefficient of linear thermal expansion is the same for both of these materials (see Figure 9).

The water vapor permeability constant at 25°C (77°F) and 50°C (122°F) has been measured as 3×10^{-8} and 4×10^{-8} gram, centimeters per hour, sq. cm., millimeter of mercury vapor pressure difference for Grades 8 and 6, respectively.

Although neither of these materials is considered to be a rapid absorber of water, both will absorb small quantities at normal service temperatures. At temperatures below 70°C (158°F) for Grade 8 and 60°C (140°F) for Grade 6 material, water absorption is slow and limited to approximately 2% by weight. This absorbed water will have a slight affect upon the strength properties of the materials because, apparently, it acts as a plasticizer. For example, the maximum flexural strength at 23°C will be reduced 3 to 5%. In addition, water entering or leaving

FIGURE 4

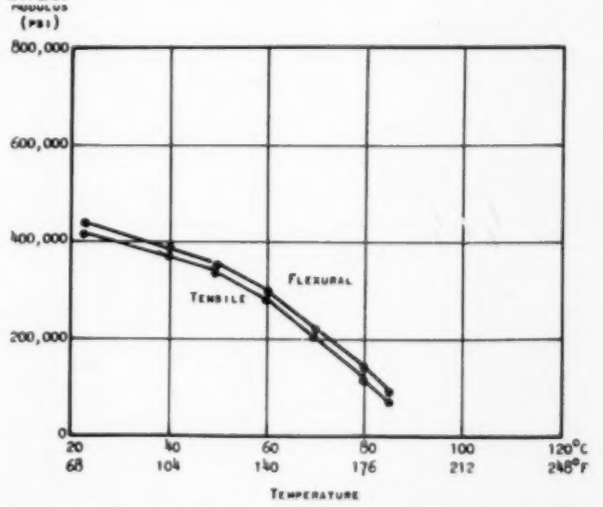
Moduli Versus Temperature of Grade 8 Acrylic Molding Powder



(Flexural modulus obtained in accordance with ASTM D790-49T; 0.250" Thick X ½" Bar, 4" span, 0.10"/Minute Crosshead Rate—tensile modulus obtained in accordance with ASTM D638-52T; 0.250" Thick Type 1 Specimen, 0.20"/Minute Crosshead Rate)

FIGURE 5

Moduli Versus Temperature of Grade 6 Acrylic Molding Powder



(Flexural modulus obtained in accordance with ASTM D790-49T; 0.250" thick X ½" bar, 4" span, 0.10"/Minute Crosshead rate—tensile modulus obtained in accordance with ASTM D638-52T; 0.250" thick Type 1 specimen, 0.20"/Minute crosshead rate)

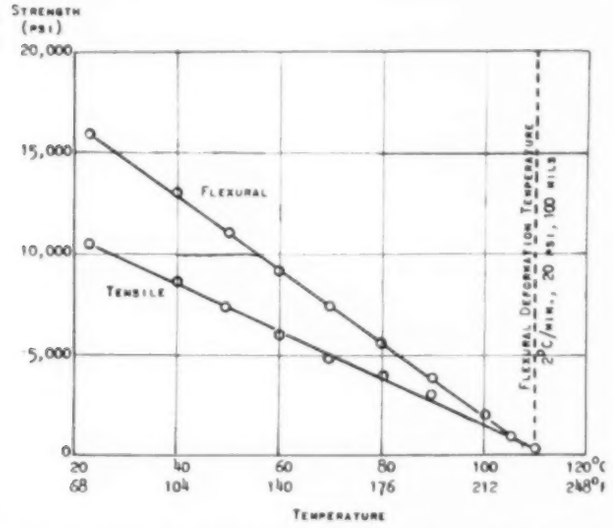
these materials has been known to produce a stress system which temporarily affects crazing resistance. Fortunately, water absorption is completely reversible; drying a water-soaked piece drives the water out of the material and the initial weight, strength and crazing resistance are regained.

It is well-known that the results of strength tests are affected by the rate of load application. Consequently, in any design calculations it is desirable to consider the creep or deformation of the loaded material versus time and temperature. A method of test has been devised (Reference 8) to measure a time and temperature dependent flexural modulus of elasticity. Data from such tests on annealed ¼" x 1" x 7" injection molded bars of Grades 8 and 6 acrylic are shown in Figures 10 and 11. These tests were made at constant loads of 500 and 1000 psi and indicate the materials will creep excessively at temperatures over 70°C (158°F) and 60°C (140°F) for Grades 8 and 6, respectively, when the materials are significantly stressed. Similar, but limited, tests on 0.08" thick moldings give somewhat different moduli. Until the factors influencing the results can be completely understood, the results in Figures 10 and 11 should be considered as guides only.

The data presented on test specimens differentiates between these two acrylic molding materials and indicates the major temperature limitations of each material. The data of Figure 3 show a change of deformation temperature for different applied stresses. The increase of flexural deformation temperature is particularly noteworthy as the stress approaches zero. Therefore, it is reasonable to expect that the maximum service temperature of acrylic moldings will be dependent upon the stress in the material. Such stress must be considered to be a combination of externally applied stress and internal or intrinsic stress; the latter being "built-in" at the time of molding.

FIGURE 6

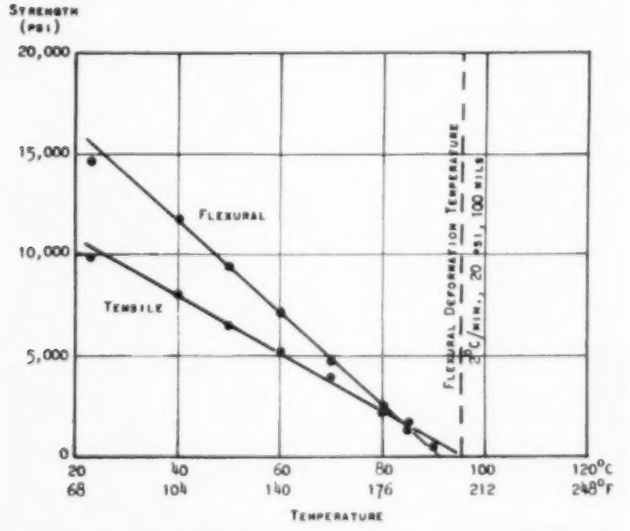
Strength Versus Temperature of Grade 8 Acrylic Molding Powder



(Flexural strength obtained in accordance with ASTM D790-49T; 0.250" thick X ½" bar, 4" span, 0.10"/Minute Crosshead rate—tensile modulus obtained in accordance with ASTM D638-52T; 0.250" thick Type I specimen. 0.20"/Minute crosshead rate)

FIGURE 7

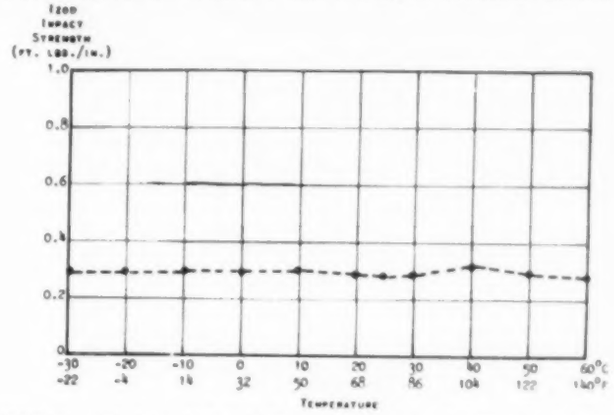
Strength Versus Temperature of Grade 6 Acrylic Molding Powder



(Flexural strength obtained in accordance with ASTM D790-49T; 0.250" thick X ½" bar, 4" span, 0.10"/Minute Crosshead rate—tensile modulus obtained in accordance with ASTM D638-52T; 0.250" thick Type I specimen. 0.20"/Minute crosshead rate)

FIGURE 8

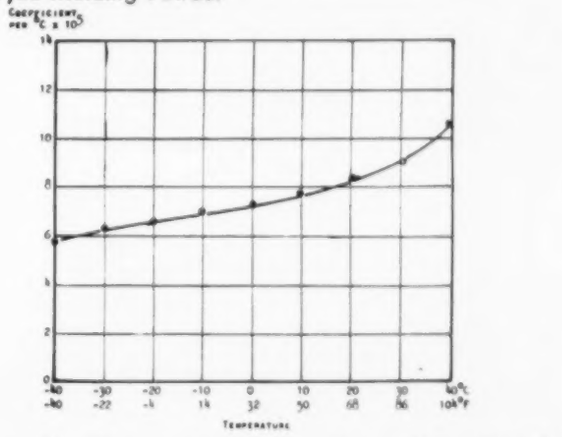
Izod Impact Strength (ft.-lbs. per inch of notch) Versus Temperature of Grades 6 and 8 Acrylic Molding Powder



(Milled notch in a ¼" x ½" x 2½" bar struck edgewise in accordance with ASTM D256-47T)

FIGURE 9

Coefficient of Linear Thermal Expansion of Grades 6 and 8 Acrylic Molding Powder



(Change of length measurements were made on a ¼" x 1" x 10" specimen to the nearest 0.0001" versus temperature)

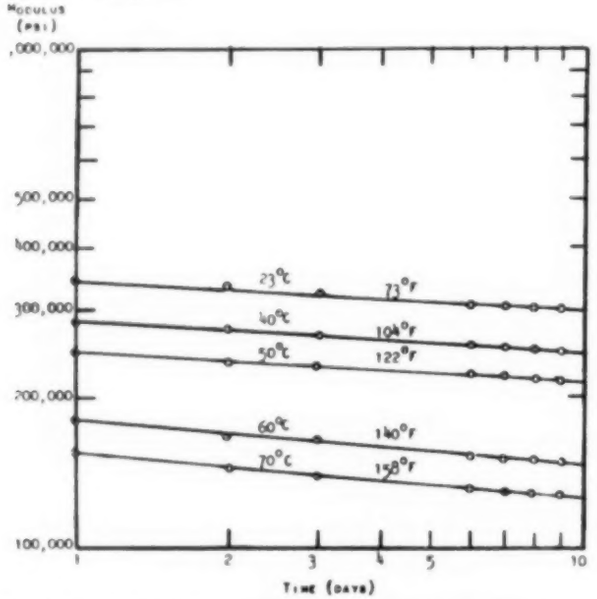
Temperature Characteristics of Molded Dial Covers

In view of the probable effect of molding stresses upon these major temperature limitations, it is necessary to study a commercial-type molding in addition to standard test bars to finally fix the material performance characteristics. To do this, numerous injection moldings were made of Grade 8 and Grade 6 acrylic molding powders in the form of a 0.08" thick Zenith radio dial cover (Figure 12, the gate area is shown by the arrow).

These dial covers were molded in a 12-ounce Watson-Stillman injection molding machine fitted with a 6-ounce heating cylinder and a cored, water-cooled mold. The molding conditions are given in Table I. The commercially-accepted covers are denoted by a "good" appearance.

FIGURE 10

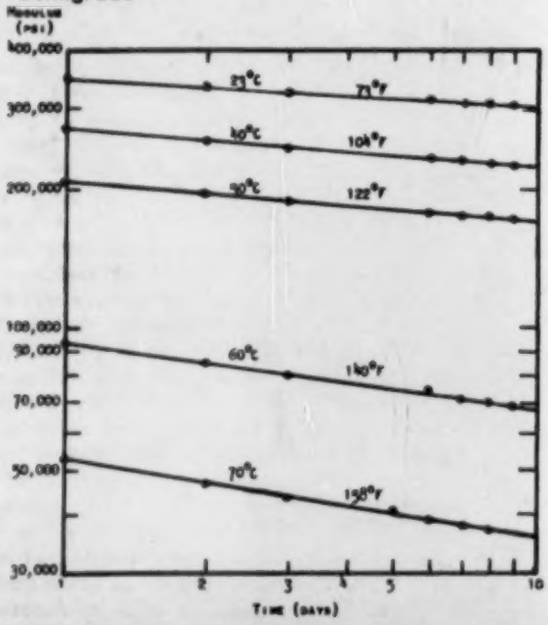
Flexural Modulus of Elasticity Versus Time of Grade 8 Acrylic Molding Powder at Various Temperatures in Degrees Centigrade



(Moduli calculated from center deflection of continuously, uniformly stressed 1/4" x 1" x 14" injection molded beams)

FIGURE 11

Flexural Modulus of Elasticity Versus Time of Grade 6 Acrylic Molding Powder at Various Temperatures in Degrees Centigrade



(Moduli calculated from center deflection of continuously, uniformly stressed 1/4" x 1" x 14" injection molded beams)

TABLE I

Molding Conditions for Zenith Radio Dial Covers
(wall thickness = 0.08"; width = 13")

GRADE 8 ACRYLIC POWDER

Molding Group	Temperature (°F) Mold	Cylinder	Pressure (psi)	Appearance
A	low (140)	low (420)	22,600	good
B	low (140)	med. (455)	17,300	good
C	low (140)	high (490)	16,200	good
D	high (185)	low (420)	22,400	good
E	high (185)	med. (455)	17,300	good
F	high (185)	high (490)	18,400	rippled surfaces
G	high (185)	high (490)	18,400	slight rippling
H	high (185)	high (490)	17,800	slight rippling
I	high (185)	high (490)	17,800	good

GRADE 6 ACRYLIC POWDER

Molding Group	Temperature (°F) Mold	Cylinder	Pressure (psi)	Appearance
M	low (130)	low (410)	19,100	good
N	low (130)	med. (450)	16,800	good
O	low (130)	high (480)	13,300	good
P	high (170)	low (410)	19,100	good
Q	high (170)	med. (450)	16,200	sinks at gate
R	high (170)	high (480)	14,500	sinks at gate, bowed

Notes: (1) Total mold closed time — 54 seconds for all groups.
Piston forward time was 7 seconds for all groups except H and I; the time for these was 7-½ and 8 seconds, respectively.
(2) All parts were cooled in still, room temperature air after removal from mold.
(3) Cold-mold-to-cold-piece shrinkage for all specimens was greatest (approximately 0.6%) between the lower corners across the circular cut-out (see Figure 12).

In these studies, it was intended that only the mold and material temperature would be varied. However, minor adjustments were made in injection pressure to eliminate sticking and a second similar batch of Grade 8 material was used to mold Groups G, H and I. These groups were molded to obtain optically satisfactory parts; achieved by increasing the piston forward time.

Due to the different molding conditions, some of the groups of specimens would be expected to deform more readily at high temperatures than others. In this study, measurements were made to the nearest 0.001" across the circular cut-out and also from the gate across the narrow portion of the molding. The specimens were then placed on flat, glass platens in circulating air ovens at various temperatures, were heated for 1 hour, cooled and re-measured. In every instance, the deformation across the cut-out was greater; this measurement is reported herein.

Such measurements gave data showing the deformation of each molding group versus several temperatures. However, Table II lists only that temperature (defined herein as deformation temperature) for each group which produced approximately 1% deformation.

It has been customary to recommend that acrylic moldings be stress-relieved or annealed at temperatures 5°C (9°F) below the deformation temperature. The reduced temperature is used to preclude the excessive deformation which would occur if annealing oven temperatures fluctuate excessively. Shrinkage resulting from annealing on flat, glass platens for 4 hours was measured on five moldings per group. Data from these measurements are shown in Table III.

TABLE II

Deformation Temperature of Zenith Radio Dial Covers (after 1 hour at indicated test temperature)

Temperature		Grade 8			Grade 6		
Mold	Cylinder	Molding Group	Temperature (°F)	Change (%)	Molding Group	Temperature (°F)	Change (%)
low	low	A	185	0.8	M	158	1.0
"	medium	B	194	1.1	N	"	0.6
"	high	C	"	1.0	O	"	0.6
high	low	D	185	0.5	P	158	0.8
"	medium	E	194	1.0	Q	"	0.6
"	high	F	"	0.9	R	"	0.4
high	high	G	194	1.0	R	160	0.7
"	"	H	"	0.9	—		
"	"	I	"	1.0	—		

These data show the greater stability of those moldings made with higher material temperature.

TABLE III

Dimensional Change of Zenith Radio Dial Covers (after annealing for 4 hours at indicated temperature)

Temperature		Grade 8			Grade 6		
Mold	Cylinder	Molding Group	Temperature (°F)	Change (%)	Temperature (°F)	Group Molding	Change (%)
low	low	A	176	0.8	M	149	0.6
"	medium	B	185	0.8	N	"	0.4
"	high	C	"	0.8	O	"	0.4
high	low	D	176	0.5	P	149	0.4
"	medium	E	185	0.5	Q	"	0.3
"	high	F	"	0.5	R	154	0.6
high	high	G	185	0.7	—		
"	"	H	"	0.5	—		
"	"	I	"	0.6	—		

These dimensional changes are less than those observed at the deformation temperature (Table II) although the exposure was 4 hours instead of 1 hour.

Some of these annealed parts were re-heated for 1 hour at the previously determined deformation temperature. After cooling, the dimensions were re-measured. These data are shown in Table IV.

As a further test of the quality of the various moldings, crazing tests were made. This was done by dipping the molded parts into ethyl acetate at room temperature for 2 minutes for Grade 8 material or 15 seconds for Grade 6 material. No crazing occurred on any annealed cover; the results for the unannealed covers are shown in Table V.

The optimum resistance to crazing was obtained on the annealed specimens. The optimum resistance of the

TABLE IV

Total Dimensional Change of Zenith Radio Dial Covers (after annealing for 4 hours and re-heating for 1 hour at deformation temperature)

	Grade 8 Temperature (°F)				Grade 6 Temperature (°F)		
Molding Group	Annealing	Deformation	Change (%)	Molding Group	Annealing	Deformation	Change (%)
A	176	185	0.9	M	149	158	0.8
B	185	194	1.2	N	"	"	0.5
C	"	"	0.9	O	"	"	0.6
D	176	185	0.5	P	149	158	0.7
E	185	194	0.7	Q	"	"	0.4
F	"	"	0.6	R	154	162	0.8
G	185	194	0.9	—			
H	"	"	0.8	—			
I	"	"	0.9	—			

These data show that annealed moldings are dimensional stable at high temperatures; the additional dimensional change produced by the second, higher temperature was approximately 0.1 to 0.3%. When dimensional changes in high temperature service must be minimized, adequate annealing is vital.

TABLE V

Crazing Tests of Zenith Radio Dial Covers (after dipping in ethyl acetate)

Temperature		Grade 8 (not annealed)		Grade 6 (not annealed)	
Mold	Cylinder	Molding Group	Degree	Molding Group	Degree
low	low	A	severe	M	severe
"	medium	B	minor	N	"
"	high	C	"	O	minor edge
high	low	D	minor edge	P	minor
"	medium	E	minor edge	Q	minor
"	high	F	minor edge	R	minor edge
high	high	G	minor edge	—	
"	"	H	minor edge	—	
"	"	I	minor edge	—	

"as-molded" specimens of Grade 8 material was obtained on those moldings made with high mold temperatures, irrespective of material temperature (as indicated by the cylinder temperature). Conversely, the optimum resistance of the "as-molded" Grade 6 specimens was obtained on those moldings made with high material temperatures, irrespective of the mold temperature. Nevertheless, when the three molding groups (P, Q and R) made with high mold temperatures are considered as a whole, the superior crazing resistance of parts made with hot molds is again substantiated.

To evaluate the efficacy of annealing, additional annealed covers of both grades of material were subjected to a very rigorous crazing test. The relative rating of the craze-sensitivity of the annealed covers was the same as shown in Table V. Thus, the effects of cold-molding were not completely eliminated by annealing and the use of high temperatures during molding plus a subsequent annealing is recommended. It is fortunate, but not unforeseeable, that such treatment produces parts with good crazing and high temperature resistance.

The data (Table II and IV) indicate that Zenith radio dial covers of Grade 8 material with an intermediate or high cylinder temperature (groups B, C, E, F, G, H, and I) have a superior resistance to high temperature. Of these groups, optimum heat and crazing resistance combined with good appearance were obtained with Group I. Thus, for this dial cover and within the variations studied, the optimum molding conditions are:

Mold Temperature — 185°F (85°C)
Cylinder Temperature — 490°F (254°C)

The optimum cylinder temperature for these parts is in contradiction to the lower cylinder temperature recommended in Reference 9.

The data presented for the various groups of molded dial covers of Grade 8 material show that by proper adjustment of the mold temperature and cylinder temperature it is possible to produce a craze-resistant, optically satisfactory cover and increase the maximum high temperature resistance of an unstressed part by approximately 10°F. Undoubtedly, the superiority of these parts occurred because lower intrinsic stresses were molded in at the higher temperatures.

Contrary to the experience with Grade 8 covers, the high temperature resistance of Grade 6 covers is only slightly affected by molding conditions (see Tables II and IV). This is probably due to the fact that Grade 6 material is softer and can be molded over a wider range of conditions than was used in this study.

For Grade 6 material, the optimum heat and crazing resistance combined with good appearance were obtained with Group O. Thus, for this dial cover and within the variations studied, the optimum molding conditions are:

Mold Temperature — 130°F (54°C)
Cylinder Temperature — 480°F (249°C)

Based on the experience with the Grade 8 material, it is probably possible to mold optically good covers of Grade 6 material with slightly greater heat and crazing resistance using high mold and material temperatures. This would require adjustments of injection pressure and cycle timing.

Conclusions

The data presented point out the major temperature limitations of Grades 8 and 6 acrylic molding powder. The data show that the highest resistance to service temperatures will be obtained with Grade 8 material, irrespective of the molding conditions of either material. The maximum permissible service temperature of a particular part will depend on the shape of the part, the imposed stress, the length of time the part is subjected to stress and the desired service life.

Superimposed on these major temperature limitations is a minor variation of resistance to temperature produced by variations of molding conditions. For the thin-walled, large area part studied, this variation is approximately 10°F for Grade 8 molding powder, and was produced by changing the mold temperature and cylinder temperature.

The variation is less for covers molded from Grade 6 material. This lesser variation is probably due, in part, to the character of the material and, in part, to the fact that the maximum possible mold and cylinder temperature variation was not studied.

Variations of other molding conditions such as pressure, timing, etc. could be expected to produce additional variation of temperature resistance and should be studied. In addition, other designs of moldings will probably give different results and should be studied.

REFERENCES

(1) A.S.T.M. D788-48T, "Tentative Specifications for Methacrylate Molding Compounds" A.S.T.M. Standards on Plastics, May 1954, pps. 104-106

(2) A.S.T.M. D648-45T, "Tentative Methods of Test for Heat Distortion of Plastics" A.S.T.M. Standards on Plastics, May 1954, pps. 532-534

(3) J. J. Gouza and W. F. Bartoe, "The Significance of Heat Distortion Temperature Measurements in the Evaluation of Thermoplastics" Society of Plastics Engineers, 11th Annual National Technical Conference, Vol. 1, pps. 459-477

(4) A.S.T.M. D790-49T, "Tentative Methods of Test for Flexural Properties of Plastics" A.S.T.M. Standards on Plastics, May 1954, pps. 518-522

(5) A.S.T.M. D638-52T, "Tentative Method of Test for Tensile Properties of Plastics" A.S.T.M. Standards on Plastics, May 1954, pps. 197-211

(6) W. F. Bartoe, "Methods of Study of High-Temperature Properties of Plastics" Modern Plastics, Vol. 33, No. 1, September 1955, pg. 151

(7) A.S.T.M. D256-47T, "Tentative Methods of Test for Impact Resistance of Plastics and Electrical Insulating Materials" A.S.T.M. Standards on Plastics, May 1954, pps. 535-540

(8) C. H. Weber, E. N. Robertson and W. F. Bartoe, "Time-and Temperature-Dependent Modulus Concept for Plastics" Industrial and Engineering Chemistry, Vol. 47, July 1955, pps. 1311-1316

(9) O. L. Pierson, "Effects of Molding Conditions on Properties of Acrylic Parts" Production Engineering and Management, November 1948

ACKNOWLEDGMENT

We are indebted to Messrs. J. R. Hiltner, Research Supervisor; W. F. Bartoe, Physics Laboratory Head; and G. G. Freygang of our Plastics Development Laboratory for numerous suggestions which were helpful in planning this work. We are pleased to acknowledge the additional help of Mr. Freygang in expertly supervising the molding of all test pieces and the help of members of the Physics Laboratory for performing the many tests reported here.

Flow Behavior of PHENOLICS Under Molding Conditions

By D. I. Marshall

Bakelite Company, Div. of Union Carbide and Carbon Corp.

The molding of phenolic compounds has been a useful art for many years. Flow behavior at molding temperatures has become increasingly more critical to the molding operation because of new, faster molding techniques, automatic machines, and larger molds. In spite of the recognized importance of flow behavior, progress in making fundamental measurements and in interpreting molding behavior has been slow. The unstable nature of the materials and their complex composition are the chief barriers to this progress.

Numerous empirical tests have been used to measure plasticity and hardening speed, the best known being the Rossi-Peakes flow tester (1) and the ASTM Molding Index (2). More recently some European publications have featured new test methods. Chatain (3) and Von Meysenbug (4) describe tests similar to the Peakes flow test but operating at higher pressures. Kanavetz (5) has constructed a cup mold capable of acting as a rotational viscometer and giving a continuous record of viscosity changes during hardening. In spite of the many test methods that have been devised, information on the nature of the consistency curve of hot molding compounds has not appeared at this writing.

Flow properties of phenolic resins are well known. Novolak resins have been studied in detail, (6,7) and viscosity changes in thermosetting resins have been measured by the parallel plate Plastometer method (8). This paper compares filled molding compositions to the phenolic resins by delineation of the true non-Newtonian flow characteristics of the molding compounds, including the measurement of changes during hardening. A beginning has been made on the problem of relating these properties to molding behavior.

Preliminary Flow Characterization

To determine the type of flow curve found with filled phenolic resins some preliminary work was done with a rotating cup viscometer. The instrument used has been described in the literature (9). The compound was thermally stable, being a mixture of 40% phenolic novolak and 60% powdered mica filler.

Poor adhesion between material and viscometer surface, and the need for pressure to densify the material seriously hampered this kind of measurement. One consistency curve was obtained on the mica-filled mixture, however. Figure 1 shows the plot of shear rate versus shear stress obtained at 120°C. It is clear that this material falls into the class known as plastic flow with shear-rate thinning. It shows a high yield value and a high degree of departure from Newtonian behavior. There were indications of thixotropy, also, but the details of this effect were not clear.

Such complex flow behavior needs the complete curve for its characterization. Within a family of materials, however, such as a group prepared from the same raw materials, or a given material in various stages of hardening, it should be possible to approximate the differences between samples with two points. The yield value and one or two points on the flow curve should be enough in many cases.

Knowing the class of flow behavior into which mold-

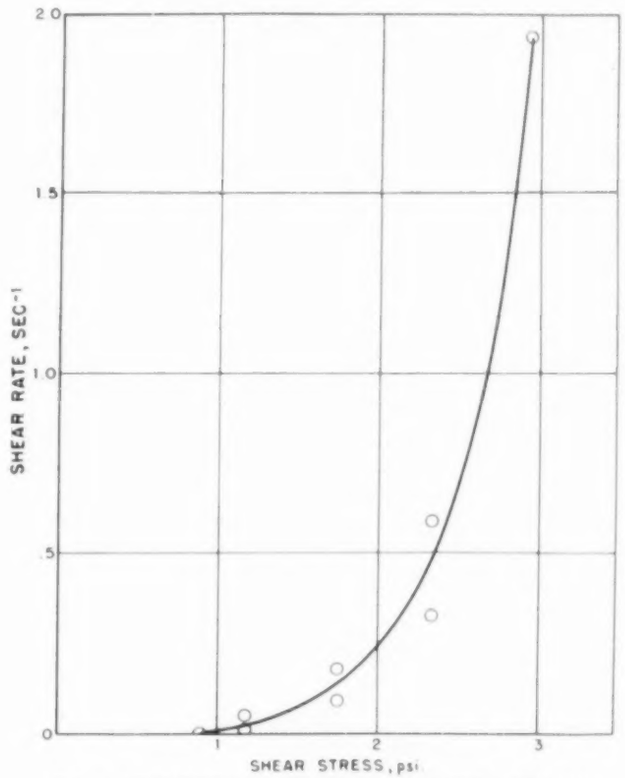


FIG. 1, CONSISTENCY CURVE AT 120°C FOR NOVOLAK WITH 60% POWDERED MICA

ing materials fall, tests can be devised for measuring such properties as yield value and points along the flow curve. These tests need to be capable of use with thermally unstable materials and of following changes caused by hardening. The sections to follow describe such tests.

Experimental Methods

Most of the test samples used were commercial molding powders of the general purpose type with woodflour filler. In some cases, special fast or slow hardening types were used, and some special laboratory preparations were non-hardening. Results reported here were obtained on the general purpose types unless otherwise stated.

Three methods were used to study the flow properties. Yield values were measured with a parallel plate compression test, the flow curves were measured with an extrusion Plastometer, and molding tests were carried out with flash-type compression cup molds. The procedures and basic equations are described below.

The parallel plate Plastometer test for yield value employed apparatus that has been described in the literature (10). The only change was the addition of loading weights to permit loads up to 650 pounds.

The measurement of yield value is based on the viewpoint that the material in a compression test will flow as long as the shear stress at some point exceeds the yield value. As the sample is pressed to a smaller thickness and larger diameter, the stress will fall until it no longer exceeds the yield value at any point. No more flow can take place under these conditions, and the highest stress value in the sample must be the yield value.

The test is carried out as illustrated in Figure 2. A pressed tablet of molding powder approximately one inch in diameter and 0.2 inches thick is placed between two heated platens and a load applied. Loads of 150 to 650 pounds have been used, the heavier loads being preferable. Pressures usually range from 100 to 300 psi on a sample pressed with 650 pounds. The material quickly softens and is pressed to a thickness of less than 0.100 inches. After one or two minutes, deformation stops. The thickness of the sample at this point is used to calculate the yield value. Tests over a range of temperatures revealed that, under these conditions, thermosetting reaction does not interfere at temperatures up to at least 150°C.

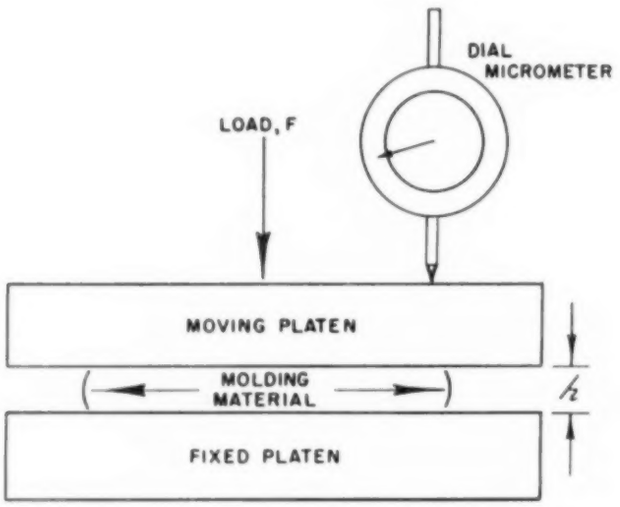


FIG. 2, SCHEMATIC PICTURE OF THE YIELD VALUE TEST.

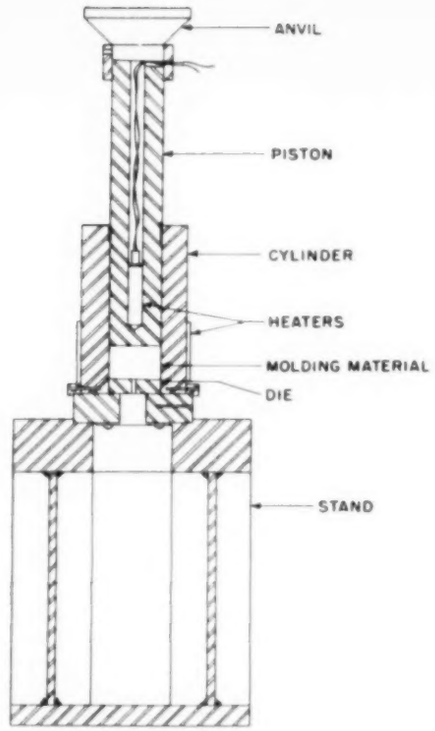


FIG. 3, CROSS SECTION OF THE THERMOSETTING EXTRUSION PLASTOMETER.

The yield value calculation is based on the pressure distribution as reported by Dienes, (10) from which the stress distribution was derived. It is assumed that the material transmits pressure hydrostatically, and that there is no slip at the wall. The highest stress value is a sample of thickness, **h**, and volume, **V**, being pressed by a force, **F**, is

$$\tau_m = 2\pi^{1/2} h^{5/2} F / V^{3/2} \qquad (1)$$

When flow stops τ_m equals the yield value, τ_o. This derivation is given in Appendix A of this paper. Equation 1 can be rearranged to

$$h = K F^a V^b \qquad (2)$$

where **K** is a constant containing the yield value, τ_o, **a** is —0.40, and **b** is 0.60.

The values of **a** and **b** can be experimentally tested by pressing samples covering a range of loads and sample sizes. This was done for several types of materials with results as listed in Table I.

TABLE I

Experimental Test of a and b Values for Equation 2

Type of Material	a	b
Wood Filled	— .389 ± .020	.633 ± .014
Mica Filled	— .443 ± .024	.574 ± .028
Flock Filled	— .545 ± .034	.616 ± .017
Modeling Clay	— .435 ± .045	.598 ± .049
Theoretical	— .40	.60

Three types of molding compounds and a sample of modeling clay are represented. The modeling clay was occasionally included in tests because it had a flow curve at room temperature similar to those of the phenolic compounds at molding temperatures.

The greatest departure from the predicted relation-

ship between **h** and **F** appeared in the case of cotton flock filler. All others gave results close to the predicted values. Based on these results, equation 1 was accepted for computing the highest stress value, or, when deformation has stopped, the yield value.

The change in yield value during hardening may be measured by a technique of preheating the resin in the form of a thin layer before applying the full load. The hardening curves obtained in this way may be compared with those obtained in extrusion or other viscosity tests to give a more complete picture of thermal hardening.

To measure flow curves and apparent viscosity values, extrusion plastometers of the plunger-driven type were used. In the case of thermally stable materials or molding compounds at moderate temperatures, a device similar to the ASTM flow rate test apparatus (11), with $\frac{3}{8}$-inch diameter piston, was used. The piston was activated by the flow tester loading mechanism, (1) giving pressures up to 2400 psi.

To measure thermal hardening and to test reactive materials at higher temperatures, a thermosetting extrusion Plastometer was designed. Figure 3 reveals the construction of this thermosetting extrusion plastometer. The unit is placed on the table of a 60,000 lb. hydraulic testing machine, and the pressure is measured with a testing machine load cell. The piston is 2 inches in diameter, giving a highest pressure of 19,000 psi. The material is heated to the cylinder temperature by dielectric heating and immediately charged into the extruder cylinder. The testing machine is then driven at a uniform speed to extrude material through the die. The changing pressure required to maintain the constant extrusion rate is observed as a measure of thermal hardening.

Knowing pressure and extrusion rate, the apparent viscosity may be computed by means of the Poiseuille relation. Because of the non-Newtonian flow curve, the apparent viscosity has a different value at each shear stress or relative shear rate value. It is necessary, therefore, to state either the shear stress or shear rate when

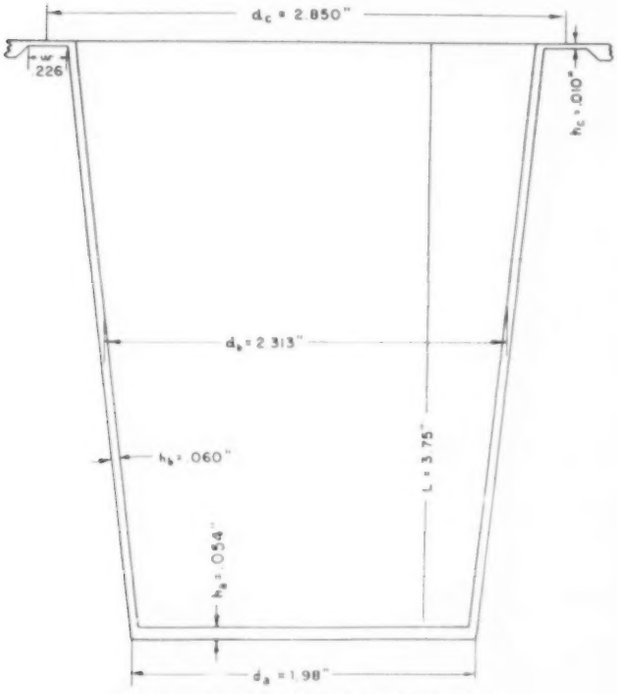


FIG. 4, DIMENSIONS OF THE TUMBLER MOLD.

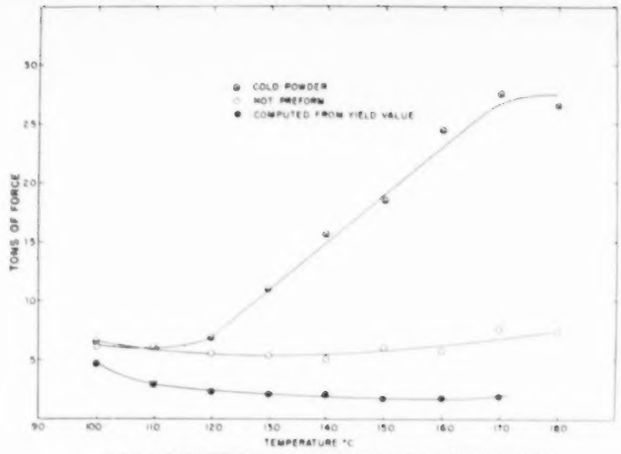


FIG. 5, CLOSING FORCE FOR TUMBLER MOLD, FAST HARDENING MATERIAL

an apparent viscosity value is reported. The shear stress at the wall of the tube in capillary flow is given by

$$\tau = PR/2L \qquad (3)$$

where P = the pressure causing flow through the tube
R = the radius of the tube
L = the length of the tube

The relative shear rate is given by

$$D = 4Q / \pi R^3 \qquad (4)$$

where D = the relative shear rate at the wall
Q = the volume rate of discharge

The relative shear rate given by (4) is useful only to approximate the flow curve. Without knowledge of the yield value and the mathematical form of the flow curve, the true shear rate cannot be accurately determined by this method.

Cup molding tests were carried out with two different sizes of flash type cup molds. Measurement of the force required to close the mold was made with a tumbler mold having the dimensions given in Figure 4. Some additional work was done with a large cup having a diameter of five inches, a depth of four inches, and a wall thickness of 1/16 inch. Electronic preheat was used in most experiments in an attempt to obtain isothermal conditions for the measurements. All presses were equipped with regulators for a wide range of pressure values.

Theory of Lowest Closing Force

The lowest force that will fill out a compression mold is expected to depend on the yield value of the material—particularly with the flash type of mold. As in the case of the parallel plate compression test, flow will stop when the imposed stress value drops to the yield value. If the material is hardening as the mold closes, the yield value will increase with time, and flow will stop when the curve of yield value versus time intersects the curve of highest stress versus time. When the resin partially hardens as the mold is closing, the lowest force that will close the mold will be higher than that calculated on the basis of the initial yield value. The difference is an indication of the amount of reaction that has taken place as the mold was closing.

Based on this reasoning, an attempt was made to derive an equation relating the yield value of the molding material to the force required to fill out a flash type cup mold.

The lowest closing force is defined as the force

needed to close to a given flash thickness. The mold is divided into three parts, each of which makes its contribution to the total force. The final equation is of the form

$$F = \tau_0 (A + B + C) \qquad (5)$$

where F = the force required to fill out the mold

τ_0 = the yield value of the material

$A = d_a^3 / 16\, h_a$ = a term representing the force required to fill the bottom of the cup.

$B = L\, d_b^2 / 2\, h_b$ = a term representing the force required to fill the cup wall.

$C = W\, d_c^2 / 2\, h_c$ = a term representing the force required to fill the flash.

The **L**, **D**, **W**, and **h** symbols above are defined in Figure 4.

The derivations of terms **A**, **B** and **C**, with the simplifying assumptions, are given in Appendix B of this paper. Using the dimensions of the tumbler mold, the terms may be evaluated separately to reveal the fraction of the total load required for each part of the mold. It is found that 35% is required for the flash, 61% in the wall, and 4% in the bottom.

Equation (5) may be condensed into

$$F = \tau_0 K \qquad (6)$$

where K represents the closing force constant of a given mold at a given flash thickness. For the tumbler mold used in this work, the calculated value of K was 840 in^2.

Measurements of Yield Value and Lowest Closing Force

Experiments were carried out to test the accuracy of equation (6) for predicting the lowest mold closing force. The tumbler mold described in Figure 4 was used. The force required to close this mold to a flash thickness of 0.010 inches was measured over a wide range of temperatures. Some moldings were done from cold powder, and others from preforms heated to approximately 110°C. Both sets of molding results were compared with the theoretical lowest closing force computed from the yield value as described above.

Two different molding materials were studied, one being a very fast hardening type and another being a relatively slow hardening type. Figure 5 shows the results obtained on the fast reacting material. Measured values were higher than computed values at all temperatures with both molding methods. Assuming that no hardening takes place in the yield value test, and that the differences

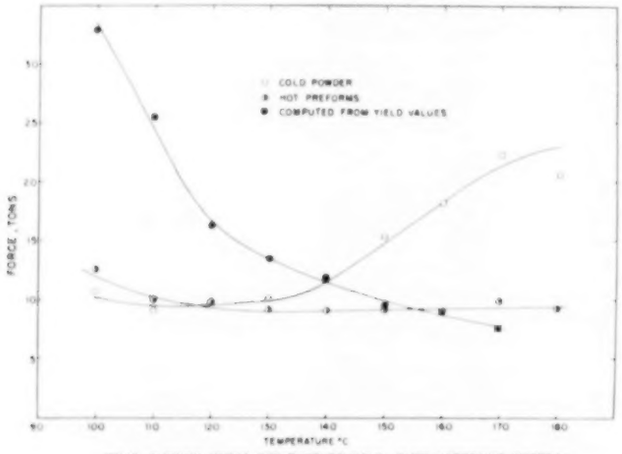


FIG. 6, CLOSING FORCE FOR TUMBLER MOLD, SLOW HARDENING MATERIAL

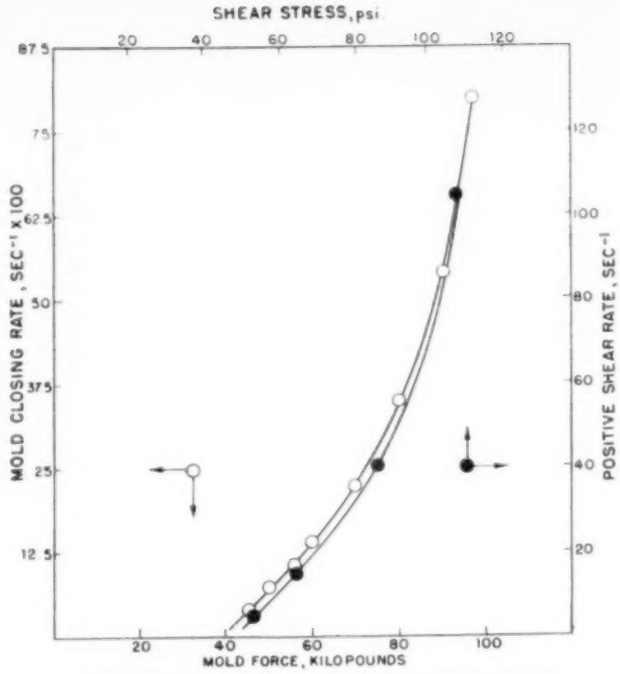


FIG. 7, SHEAR RATE VS. SHEAR STRESS IN EXTRUSION AND MOLD CLOSING RATE VS. PRESSURE AT 125°C

between measured and computed values are caused by hardening, it is concluded that all of the molding conditions permitted some hardening before the mold was closed. The hardening was far greater with cold powder than with heated preforms at the high mold temperatures.

It is evident from these results that the pressure required to mold can be several times higher than the pressure needed to form a piece from the same material without the thermosetting reaction.

To test further the accuracy of calculated values of closing force, measurements on a slow hardening material were performed. Results are plotted in Figure 6. In this case, there was less reaction during the closing stage as judged from the slow rise in closing force with increasing temperature. Furthermore, the computed values were much higher than measured values at the lower temperatures. This is taken as evidence that some assumptions made in computing the theoretical closing force were not valid. For example, the assumption of no slip at the metal surface is known from experience to be questionable. Probably every molder knows that surface effects are important. Another assumption was no thixotropic breakdown. Both of these would be greater in the molding operation than in the yield value test.

There is the question, also, of the pressure at which the tests were carried out. The yield value test may be affected by the pressure being lower, giving a lower material density than that in the mold. All of these factors could be contributing to the difference between computed and measured values. It is encouraging to obtain theoretical values of the right order of magnitude considering all of the assumptions made. An improved yield value test operating closer to molding pressures, and a consideration of slip and thixotropic effects could be expected to greatly improve agreement between theory and experiment.

The Flow Curve

The flow curve of the material as plotted in Figure 1 can be expected to control the behavior of the molding

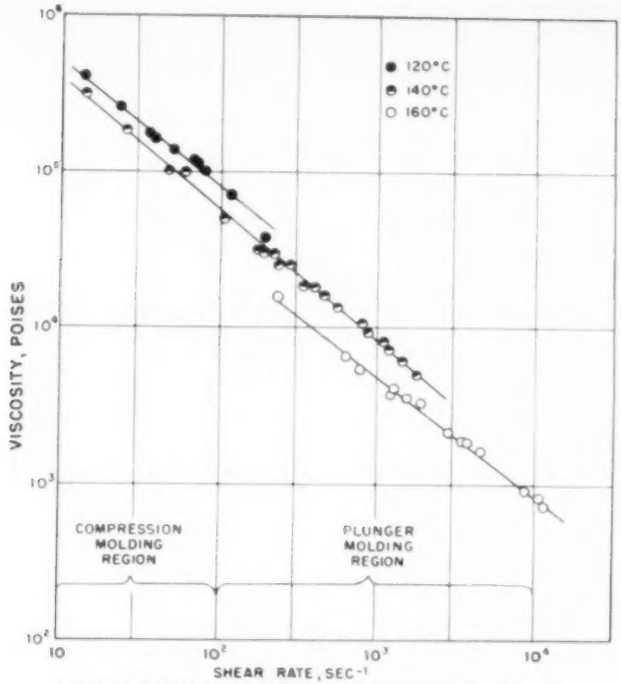


FIG. 8, CHANGE IN APPARENT VISCOSITY WITH RELATIVE SHEAR RATE FOR RESIN WITH 50% WOOD FLOUR AT DIFFERENT TEMPERATURES.

material in a molding process. Assuming for the moment no thermosetting reaction, the lowest closing force will be determined by the yield value as described in the previous section. The flow rate at any stress above the yield value will be defined by the curve itself. From this reasoning one would predict that the closing rate of a compression mold or the fill-out rate of a plunger mold would be controlled by the initial curve and by the changing curve as thermal hardening takes place.

To learn whether the closing rate of a compression mold is actually determined by the flow curve of the material, the closing rate of a cup mold was measured over a range of pressures. The cup was five inches in diameter, four inches deep, with a wall thickness of 1 16-inch. Closing rate was taken as the reciprocal of the time required for the mold to travel from .100 inches to .050 inches of flash thickness. The material was electronically preheated to the mold temperature.

In Figure 7, the closing rate is plotted against pressure and the relative shear rate is plotted against shear stress for a typical woodflour filled molding material. The scales have been adjusted so as to make the curves nearly coincide, making the similarity more evident. Within experimental error, the two properties are controlled by the same law. The generalization can be made that this would be true for any molding operation involving isothermal flow. The picture is modified for a cold powder charge, the closing of the mold in this case being controlled up to a point by the heating of the material.

No data are available comparing plunger mold filling speed with extrusion plastometer results, but considering the close similarity between the plunger mold and the extrusion plastometer, there is every reason to expect the correlation to be as good as that in Figure 7.

If the curve of relative shear rate versus shear stress is expressed as apparent viscosity versus relative shear rate on logarithmic scales, a convenient picture results. In Figure 8, the viscosity of a non-reactive resin-filler mixture at three temperatures is plotted against relative shear rate. The viscosity value that would be in effect in a molding operation may be found if the relative shear rate in the molding operation can be estimated. A few calculations were made and it was learned that compression molds usually operate in the range of 1 to 100 reciprocal seconds. Plunger molds range considerably higher—values in the gates may reach 10,000 reciprocal seconds.

The two molding zones shown on the shear rate scale in Figure 8 indicate one basic difference between plunger and compression molding. If two materials differ in their flow curves so that the curves cross, their relative plasticities may be reversed in plunger molding in comparison to compression molding. Plasticity irregularities from this cause undoubtedly have been observed by many molders.

Temperature and Hardening Reaction

It is of interest to compare the viscosity of a phenolic resin with that of a typical molding compound. Figure 9 shows a curve of viscosity versus temperature and viscosity versus time at 140°C. for a resin and a molding material. The resin curve was obtained by the parallel plate viscosity method which has been described in the literature (8). Since the resin is Newtonian over the temperature curve and the greater part of the hardening curve, the viscosity values are true absolute quantities. In the case of the molding compound, however, the non-Newtonian behavior brings about the need for two kinds of apparent viscosity values. The apparent viscosity at constant shear rate is plotted for a relative shear rate of 24 sec. This is nothing more than the change in shear stress or pressure as a con-

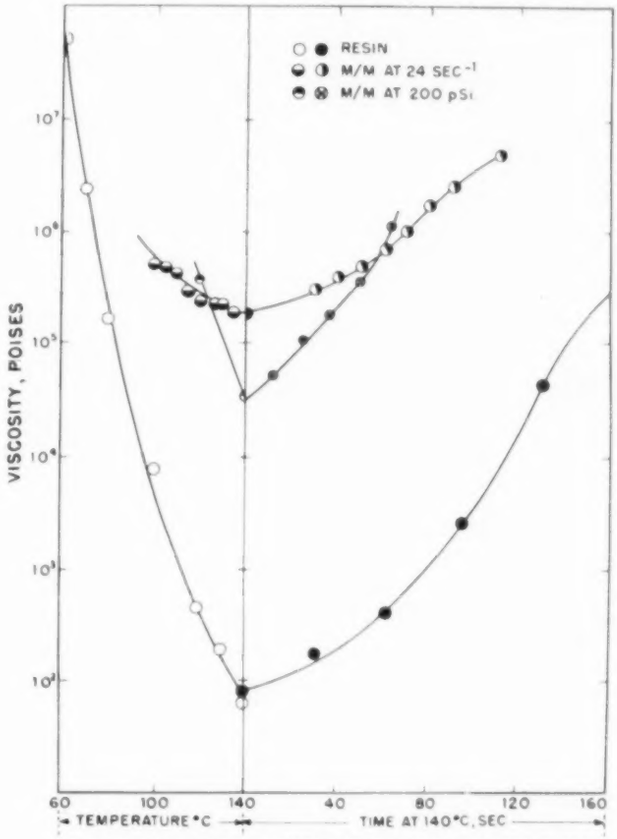


FIG. 9, VISCOSITY VS. TEMPERATURE AND VISCOSITY VS. TIME AT 140°C FOR RESIN, MOLDING MATERIAL AT CONSTANT SHEAR RATE, AND MOLDING MATERIAL AT CONSTANT STRESS.

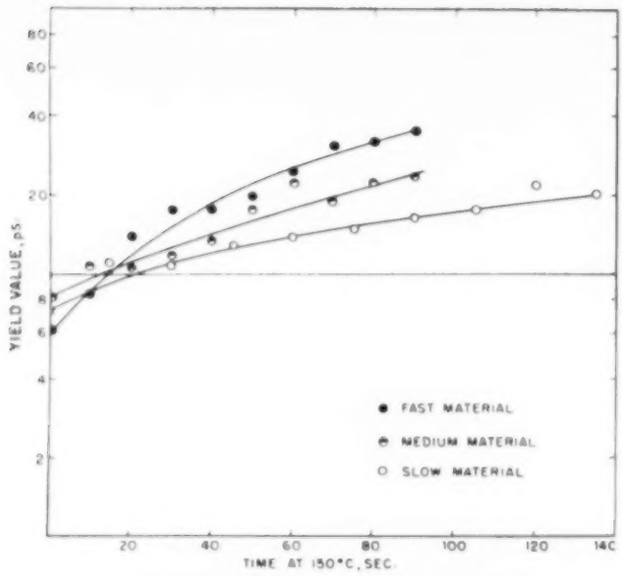


FIG. 10, CHANGE IN YIELD VALUE WITH TIME AT 150°

stant shear rate or extrusion rate is maintained. The apparent viscosity at constant stress was obtained by following the change in shear rate or extrusion rate at a constant stress of 200 psi. The viscosity at constant stress changes faster with temperature and faster with hardening than the viscosity at constant shear rate. This is the inevitable result of non-Newtonian flow. The curves for the viscosity at constant stress more closely resemble those of the resin. Table II contains values for temperature sensitivity in terms of activation energy values.

The apparent viscosity at constant stress determines how the closing speed of a mold will vary as the force is held constant. The viscosity measured at controlled rate, on the other hand, reveals variations in the force required to maintain a given closing speed. Either of these can be of practical importance to the molder. Although molding is usually done at constant press force, it is helpful to know how a change in material or temperature will affect the pressure required to maintain a given closing time.

The yield value changes with temperature to about the same degree as the viscosity at constant shear rate. The change with temperature is shown in Table II, where activation energy values are used to measure temperature sensitivity. No physical significance except temperature sensitivity is implied by these activation energies.

TABLE II

Activation Energy of Flow Properties of Resin and Molding Material

Property	Calories Per Mole
Resin Viscosity	28,000
M/M Viscosity at 100 psi	35,000
M/M Viscosity at 24 Sec.$^{-1}$	11,000
M/M Yield Value	12,000

Hardening speed measurements were made on molding compounds of widely differing hardening rate. Figures 10 and 11 show the increase in the yield value at 150°C. and the viscosity at 140°C. for the same three materials. The wide differences in reaction speed are caused by the different resins used.

The results show indications that yield value and viscosity do not increase at the same rate. This difference between the change in yield value and the change in viscosity with hardening may not be accurate because of differences that exist in the operating conditions of the two test methods. The pressure in the viscosity test ranged up to 16,000 psi, whereas the yield value test does not exceed 300 psi. Furthermore, moisture is driven out during preheat in the viscosity test method, whereas the yield value test permits very little loss of moisture either before or during the test.

It is evident from these results that improvements in these test methods are needed. These results may serve to point the way to improved test methods for future work.

Summary

The flow properties of phenolic molding compounds may be described as plastic flow with shear-rate thinning. This can be complicated by thixotropy and surface slip. The flow curve and hardening characteristics must be known

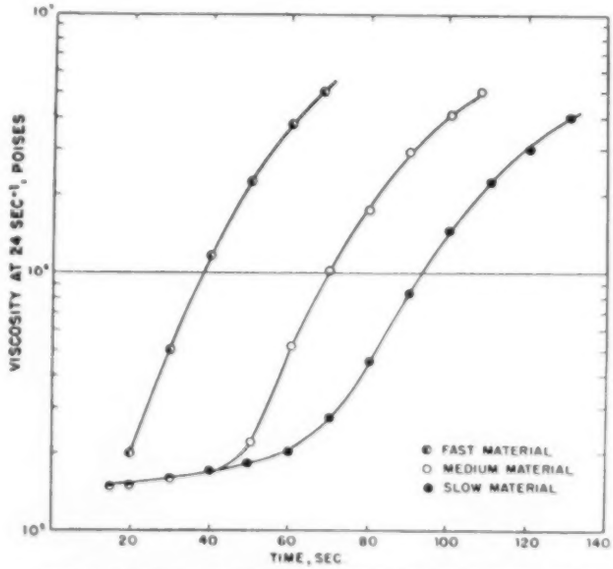


FIG. 11, APPARENT VISCOSITY AT CONSTANT SHEAR RATE VS TIME AT 140°C.

REFERENCES

1. G. L. Peakes. **Modern Plastics 14**, No. 10, p. 39 (1937).
2. ASTM Method D731-44T (1944).
3. M. Chatain. **Industrie Plastique Moderne, Paris, 5**, 37-40 Nov. 1953.
4. C. M. Von Meysenbug. **Kunststoffe 45**, 48 (1955).
5. I. F. Kanavetz. **Khim. i Fiz-Khim.** p. 204 (1952).
6. A. J. Guzzetti, G. J. Dienes, and T. Alfrey Jr., **J. Colloid Sci. 5**, 202 (1950).
7. T. T. Jones, **J. Appl. Chem. 2**, 134 (1952).
8. D. I. Marshall, **ASTM Bulletin No. 204**, p. 40 (Feb. 1955).
9. F. D. Dexter. **J. Appl. Phys. 25**, 1124 (1954).
10. G. J. Dienes and H. F. Klemm, **J. Appl. Phys. 17**, 458-71 (1946).
11. ASTM Method D 1238-52 T (1952).

in detail in order to understand the behavior of a given sample of molding powder.

In the molding of thermosetting materials, the filling of the mold is controlled by the flow curve as it changes with temperature and with thermal hardening. Flow stops when the stress value and the yield value approach each other. Methods of measuring these properties and the rate at which the properties change with thermal hardening have been developed. The information obtained is useful for predicting how the mold closing rate and the lowest pressure that will close the mold are expected to change with temperature or any other variable.

A theoretical relation between lowest closing force and the yield value was derived. Calculated values were close enough to measured values to indicate soundness of the approach and to point out possibilities for improving the theory by accounting for some flow complications not yet measured.

APPENDIX

A. Derivation of the Yield Value Equation

Consider a disk of material of radius, **R**, volume, **V**, pressed between two parallel plane surfaces with a force, **F**, the planes being separated by the material having a thickness, **h**. To compute the stress at the wall, we consider an element of material lying between the angles θ and $\theta + d\theta$, between the points **r** and **r + dr**, and having a height, **h**. The radial force on this element is $r\,d\theta\,h\,dr\,\delta p\,\delta r$. The area supporting this force at the metal surface is $2r\,d\theta\,dr$. The stress at the wall is the force divided by the area, therefore (1A)

$$\tau_w = [r\,d\theta\,h\,dr\,(\partial p/\partial r)]\,2r\,d\theta\,dr = (h/2)\,(\partial p/\partial r)$$

Dienes and Klemm (10) give the following equation for the pressure at any point along the radius of the disk:

$$p = (-3\eta/h^3)\,(dh/dt)\,(R^2 - r^2) + \pi \qquad (2A)$$

where π is the pressure at $r = R$.
They report, also, that

$$dh/dt = (-2\pi h^5 F)/3\eta V^2 \qquad (3A)$$

Substituting (3A) in (2A) and taking the partial derivative with respect to **r** one has:

$$\partial p/\partial r = -4\pi h^3 Fr/V^2 \qquad (4A)$$

Substituting (4A) in (1A) and disregarding the negative sign, there is obtained:

$$\tau_w = 2\pi h^3 F r/V^2 \qquad (5A)$$

which is the expression for the stress at the interface as a function of **r**, the distance from the center. The maximum value will be at $r = R$. **R** may be expressed in terms of **V** and **h** as

$$R = V^{1/2}/\pi^{1/2} h^{1/2} \qquad (6A)$$

Substituting (6A) in (5A) one has for the maximum:

$$\tau_m = 2\pi^{1/2} h^{5/2} F/V^{3/2} \qquad (7A)$$

When the maximum stress falls to the yield value, deformation ceases at some ultimate **h** value. The maxium stress computed for this ultimate **h** value is taken as the yield value.

B. Derivation of the Equation for Mold Closing Force

The press force that will fill out a compression type mold is related to the yield value in the same way that the parallel plate compression test is related to the yield value. To derive an expression for the closing force of a cup type compression mold, such as is shown in Figure 4, the following simplifying assumptions are used:

1. There is no slip at the metal surface.
2. The yield value is independent of strain history, pressure, and the thickness of the section.
3. Pressure is transmitted through the material according to the usual hydrostatic law.
4. The tapered wall of the cup may be approximated as an untapered annular section.
5. The flash ring may be approximated as a straight slit instead of a ring.
6. The direct shearing action from relative motion of force and chase is negligible.

Assumptions 4-6 are not necessary, but are made because they simplify the equations without materially affecting the results reported here. Assumptions 1-3 are required because of lack of basic knowledge.

It will be assumed that the closing force is the sum of three terms. The first is the force required to fill out the bottom of the cup. This will be related to the yield value as stated by equation (7A). Solving for F and substituting for V the equivalent in terms of h and d, one obtains

$$F_a = \tau_y \pi d_a^3/16\,h_a \qquad (8A)$$

The second term will be the force needed to produce the pressure that the cup wall will support without permitting flow up the sides of the cup. It is easily determined that the highest shear stress is at the metal surface and has the value of the force pushing the annular plug divided by the area of the supporting plastic-metal interface. That is:

$$\tau_b = P_b \pi d_b h_b/2\pi d_b L \qquad (9A)$$

$$\tau_b = P_b h_b/2L \qquad (10A)$$

Solving for P_b, the pressure supported by the cup wall is obtained. This may be multiplied by the area over which the pressure acts to obtain the force.

$$F_b = 2\pi d_b^2 L \tau_b/4 h_b = \tau_b \pi d_b^2 L/2 h_b \qquad (11A)$$

Flow will stop when τ_b approaches the yield value, τ_y. (11A) is the second term in the expression.

The simple way to handle the flash ring is to assume that it is the equivalent of a straight slit of width equal to πd_c. Then the third term is like the second with the thickness, length and width substituted. Substituting these into (11A) one has

$$F_c = \tau_y \pi d_c^2 W/2 h_c \qquad (12A)$$

which is the expression for the force arising from the pressure supported by the ring of flash.

The total force supported by the material in the mold is the sum of 8A, 11A, and 12A. When there is no more flow, τ_a, τ_b, τ_c equal the yield value, τ_y. Therefore

$$F = \tau_y \pi [(d_a^3/16\,h_a) + (L\,d_b^2/2\,h_b) + (W\,d_c^2/2\,h_c)] \qquad (13A)$$

The three terms may be named **A, B, C**, giving the result already reported as equation 5.

Button maker comes back big

Meet the button manufacturer who went out to get new markets and came back with a bigger button business. Like more manufacturers in more product fields today, he found molding with PLASKON® Urea and Melamine makes a major difference. These are the compounds that mold strength, extra surface hardness, durability and beauty into products that resist chipping, scratching, cracking, abrasion, and heat. The compounds that stand up to ironing and all other rigorous commercial and home laundering practices. The compounds with a range of over 12,000 colors, shades and tones. The molding materials proved superior with fast cure, ready fusibility and minimum reject rate. Yes...PLASKON Urea and Melamine can be the answer to your product problems. Find out how by call or letter to your Plaskon representative. Information and technical assistance at your service.

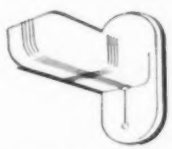
SMOOTH "SALE-ING" WITH THESE PROPERTIES IN YOUR PRODUCTS!

STRENGTH AND FINISH

Poker chips that resist chipping, are color-fast and practically unbreakable, win more sales.

DURABILITY

Radios wear beauty well with color molded in, hard surfaced housings have strong sales appeal.



TRANSLUCENCY

Lighting fixtures molded in almost any degree of translucency are assured a bright sales future.

HEAT RESISTANCE

Toasters with molded parts that are hard, durable and heat-resistant make a hot sales item.

COLOR

Colorful closures, in an unlimited range of shade, tone and hue, get attention, close more sales.

ELECTRICAL PROPERTIES

Shavers with high-safety margins, long-wearing housings, are smoother performers, better sellers.

PLASKON® UREA AND MELAMINE...LEADERS IN THE FIELD

For further information on PLASKON Plastics and Resins, address BARRETT DIVISION, Allied Chemical & Dye Corporation, Dept. 24 I, 40 Rector Street, New York 6, N. Y. Phone HAnover 2-7300.

NEW Fields For Plastics

Jean O. Reinecke

Reinecke and Associates

(Presented at the SPI Midwest Plastics Conference, April 27.)

PLASTICS AND THE industrial design profession have grown together, and neither is approaching its maturity.

The very first product designed by our office was made of plastics, and from the beginning the plastics industry has utilized design extensively.

We are both congenital aesthetes.

You have preached for years that color goes all the way through, that finishes are beautiful and tactily pleasant, and that the material can be molded into any shape—the implication being that all of these shapes are attractive.

Like the shapes of women, all plastics shapes may be beautiful—but there are degrees of beauty.

I hope the industry never forgets that it is selling appearance along with its other qualities.

However, the "New Fields" are not in the area of appearance or design but are in merchandising.

Although many of you do not sell products directly to the public but produce parts or components assembled and marketed by others, you are affected by the public acceptance of those finished products.

If you do a good job, you prosper along with your customers. If you do poorly, your sales suffer.

The best way to determine where you are going and how to get there is to look around you.

Look in all directions.

Satchel Paige says, "Never look back. Someone may be following you."

But looking back can be educational.

You can see the mistakes made by yourself and others and avoid their repetition.

Look to the sides.

What is being done in other industries?

One of the greatest enemies of dynamic growth is the too narrow interest in your own organization and industry.

Light metals, glass and many other materials are in direct competition with you, and what they are doing can be very pertinent to your business.

What is being currently done by everyone and every manufacturer affects you.

For example, business prosperity or recession is a total factor which affects you, but many less major happenings, such as a local truckers' strike, can have an even greater influence on you.

Look FORWARD.

I shall make no predictions.

You all know generally what is ahead of us in this atomic age, how solar energy, automation and the many other developments are literally bursting our previous conceptions.

There is an electric charge in the air that sets our thoughts reeling over the future.

We all have access to statistics and published projections made by economists and scientists.

We can all recognize trends.

Opportunity is all about us.

In the past 10 years population has increased 23%. Sex is holding its own.

Statisticians predict an even greater rate of increase in the next ten years, and at a reasonably predictable rate.

In these same past 10 years retail purchasing has increased 77%, and that rate is accelerating.

Possibly of greater importance than the specific new products which you will make is the expansion of the total market.

Of even greater importance is the change in market character.

Formerly we had a pyramid shaped economic market.

Here at the top are a few rich people forming a limited market.

At the bottom are the poor people—gigantic numerically but individually requiring low priced merchandise.

I suspect that the majority of business men still believe price is the number one factor in sales.

Well, the number one retailer of our country places price about fourth.

Let's look at today's market.

It is now diamond shaped.

The rich people (like material manufacturers) have been mowed down by income taxes.

The poor people now are becoming extinct and offer a market of low quantity as well as low returns.

The low price market is no longer of value, and it's overrun by retarded manufacturers.

Now let's look at the central area—the middle classes.

This center area represents 50% of the total buying units—the mass market.

Do you know the income of this group?

It is between $4,000 and $10,000!

Can we call that a destitute market?

By no means!

It is big money and it is big volume.

The meaning of our words also change.

We are told that 40% of our income is discretionary or can be used as we wish.

That implies that 60% of our income goes for necessities.

Phooie!

Take a trip through rural Mexico, and you will see what essentials are. And how very limited they are.

Also, about 50% of our purchases are made on impulse.

That means that about half of our buying depends upon DESIRE.

Now, people don't know what they want until it is offered to them.

No housewife, in 1900, said "I want an iron with a plastic handle."

Yet, today, she would buy no other type.

Today the consumer demands and will pay for features and qualities which satisfy his desires.

Although consumers are not creative, they are selective.

The demands for varied colors, variety in design and other factors which multiply standardization and distribution problems cannot be ignored.

Automation is almost here, but it will of necessity be a flexible automation—one which can quickly be altered rather than the continuous automatic production of a fixed design.

It may require such quick alterations that production is controlled by electronic computers.

Of all the directions to look for new fields look UPWARD.

We, in our office, start every project with an objective meeting in which creative thinking is demanded. Limitations imposed by practicability are ignored. Analysis and judgment come later.

I recommend this practice in the operation of your company, with periodic sessions devoted to searching the sky and getting your feet off the ground.

We, the public and the designers serving the public, need so much from the plastics industry.

We need better education of and flow of information to the engineer who specifies plastics.

We need a lower cost mold making method to provide greater flexibility and increase the potential uses of plastics.

We need higher heat resistant materials, larger pieces and quicker change-over in colors.

Entire refrigerator cabinets should be molded in some type of foam material. This may become possible for "built-in" type cabinets which are gaining popularity.

But, in looking upward don't limit your search to products only.

Use a perception of the expanding markets, a new attitude on the part of the consumer, and the value of design as your tools for entering New Fields.

Plastics, called the material of the future, the miracle material and the area of opportunity twenty years ago, today fits the description even better.

Polysulfide Liquid Polymer and Modified Epoxy Resin Casting Compounds

Alan J. Breslau and Keith R. Cranker

Thiokol Chemical Corp.

The requirements of the casting and embedment fields are stringent and varied. As a result, the casting compounds used must be extremely versatile to be of value in the many different applications normally encountered. The properties of the polysulfide liquid polymers enable them to be used in many of these applications. These polymers are low-viscosity resins which cure at room temperature to elastomeric solids. In this cured state they have excellent flexibility, dimensional stability, fair electrical properties, resistance to most chemicals and solvents, and the ability to seal out water and water vapor effectively. They may also be chemically combined with epoxy resins to take advantage of the inherent toughness and high strength of these latter resins while contributing flexibility and dimensional stability over a wide range of conditions.

The polysulfide polymers are mercaptan-terminated saturated aliphatic elastomers formed by the interaction of bis(2-chloroethyl) formal and sodium polysulfide. The liquid resins are prepared from this product by the reduction of some of the repeating disulfide linkages to terminal mercaptan groups. The resulting linear structure may be represented by

$HS(CH_2CH_2\text{-}O\text{-}CH_2\text{-}O\text{-}CH_2CH_2SS\text{-})_nCH_2CH_2\text{-}O\text{-}CH_2\text{-}O\text{-}CH_2\text{-}CH_2SH$ where n may be either 3,6 or 23 for the commercially available liquid polymers. Side mercaptan groups occur occasionally along the chain. These are derived from the one half or two mol percent of trichloropropane added for crosslinking the segments at various points. (5,21)

Several review articles (6,10,11,12,13) have been published in recent years concerning the use of epoxy resins in casting and embedment applications, yet the literature has failed to keep pace with the rapid developments in this field, and little information is available (4,5,14) concerning the use of polysulfide polymers and the polysulfide-modified epoxy compounds.

It has been stated (12) that "No single embedment compound (is) capable of yielding the many qualities required for the different embedment applications." With this thought in mind, it is our plan to indicate some of the variations in properties that are possible with the polysulfide liquid polymers by compounding and other techniques so as to satisfy the many different casting and embedment requirements. The same thing will be shown for the epoxy resins modified with polysulfide liquid polymer. In the former case the products vary from soft to tough rubber-like materials; in the latter, they vary from flexible to hard and brittle plastics.

This paper was given at the Symposium on Casting Resins by the Diamond Fuze Laboratories Jan. 1956. It was originally published in the July 1956 issue of Electronic Equipment.

It becomes convenient to group and discuss the many properties under five major headings:

1. Handling Properties

A good casting resin should be easy to handle and apply. Both the polysulfide polymer-based compounds and the modified epoxy resin compounds excel in this respect because they are low-viscosity liquids which cure at room temperature to solids having a range of useful properties.

The commercially-available polysulfide liquid polymers are available in three viscosity ranges. These are shown in Table I.

TABLE I

Properties of the Thiokol Polysulfide Liquid Polymers[21]

Trichloropropane CROSSLINKING 2%	½%	n, No. of Separating Segments	No. Average Mol. Wgt.	Brookfield Viscosity Centipoises
LP-8		3-4	500-700	250-350
LP-3	LP-33	6	1,000	700-1,200
LP-2	LP-32	23	4,000	35,000-45,000

The highest molecular weight polymers, LP-2 and LP-32 are generally cured as 100 percent polysulfide polymer, although there are isolated cases where they have been used to modify epoxy resins. On the other hand, the remaining polymers, that is LP-3, LP-33, and LP-8 are almost always used as modifiers and flexibilizers for epoxy resins, although they too may be cured as 100 percent polysulfide polymer. The conversion of the LP-2 and LP-32 polymers from liquid to tough rubber (which we shall refer to as a Thiokol based compound) is carried out by oxidation which is accelerated in an alkaline medium. Metallic oxides, such as zinc oxide, may be used in the presence of hexamethylene tetramine. However, the most common curative used is lead dioxide which is usually incorporated in the polymer in paste form. Its action is very rapid, cure being accomplished in a matter of minutes. In addition, organic peroxides, such as cumene hydroperoxide, benzoyl peroxide, and tertiary butyl hydroperoxide are effective in curing the LP-2 and LP-32 polymers but these cures are less extensively used than the lead dioxide cure, particularly in electrical potting because of the poorer electrical properties associated with these cures. The lead dioxide cured-Thiokol based compounds find extensive application in electrical potting where sealing out dirt and moisture, and protection of soldered connections and delicate parts are necessary.

The epoxy or ethoxyline resins, when cured by themselves, are extremely brittle. For this reason they are cocured with either the medium or low molecular weight polysulfide polymers, LP-3, LP-33 or LP-8. (We shall re-

fer to these compounds as modified epoxy compounds.) Most epoxy resins commercially available are condensation polymers of epichlorohydrin and 2,2-bis(4-hydroxy phenyl) propane and may be either liquid or solid depending on the molecular weight. The nature of casting and embedment applications precludes the use of the solid epoxy resins except in the most unusual circumstances. Combinations of liquid and solid epoxy resin may be used, such as a combination consisting of 60 parts of Epon 828, a liquid epoxy, and 40 parts of Epon 1001, a solid epoxy which will remain liquid although of relatively high viscosity. Addition of polysulfide polymers to epoxy resin usually results in a lowering of viscosity of the latter. This effect is shown graphically in Figure I for the LP-3 polymer with several commercial epoxy resins. Still greater reductions in viscosity can be attained by the use of LP-8 or with small amounts of reactive diluents such as allyl-or phenylglycidyl ether. However, this is at the sacrifice of some of the other properties.

The cure of the epoxy resins, with or without polysulfide polymer, may be effected with mineral and organic acids and anhydrides, bases, particularly amines of all degrees and types, and other resins such as urea-, phenol-, and melamine-formaldehydes. Several studies of the cure mechanisms involved may be found in the literature. (5,8,11,16,19)

The cure of both the Thiokol based compounds and the modified epoxy compounds are exothermic reactions. With the Thiokol based compounds this heat of reaction is negligible since the temperature due to the exotherm rarely exceeds 100 degrees Fahrenheit. With epoxy compounds and modified epoxy compounds, this problem becomes more serious because the heat generated during the cure may be appreciable enough so as to damage the components being embedded. The temperature due to reaction exotherm is a function of the rate of cure, the mass of resin undergoing cure, the container in which the cure is taking place, the components being embedded and the ambient conditions. There are several techniques available for overcoming this cumulative heat effect. Some of these are obvious, such as internal or external cooling or casting smaller amounts of material at a time, allowing gelation to occur before casting the next portion. A practical technique is to retard the rate of cure sufficiently to permit the heat to dissipate. This may be done by pre-cooling the reactants prior to mixing, by the addition of chemical retarding agents, by using less active curing agents (some of which require the addition of external heat to effect a cure), or within limits, using lesser amounts of curing agent.

A wide selection of curing agents permits a reasonable control of the curing rate of the polysulfide-modified epoxy resin systems. Very rapid cures, requiring as little as three minutes, may be obtained with dimethylaminopropyl amine; more normal cure times may be obtained with such agents as triethylene tetramine (TET) or tri-dimethylaminomethyl phenol (DMP-30-Rohm and Haas Co.). A fifty-gram mass of resin with either of these curing agents cures in from 15 to 30 minutes. For slower cures, dimethylaminomethyl phenol (DMP-10-Rohm and Haas Co.) or piperidine are recommended. Agents such as meta-phenylene diamine require heat from an external source to cure. In Table II the maximum temperature due to reaction exotherm is recorded for a Bakelite epoxy resin, ERL 3794 with different amounts of LP-3. These tests were run on fifty gram batches in paper cups starting at 76°F. Two different curing agents are illustrated; a primary aliphatic amine (TET), and a tertiary aromatic amine (DMP-30). Increased amounts of LP-3 tend to retard the cure rate although the formulations containing the lower amounts of LP-3 cure more rapidly than the unmodified epoxy resin.

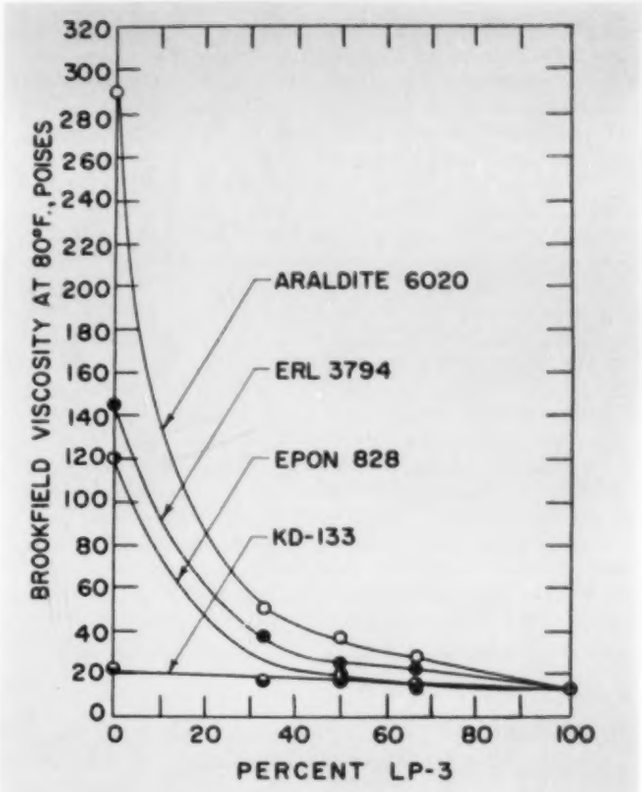


FIG. 1 EFFECT OF LP-3 ADDITION ON VISCOSITY OF EPOXIES

TABLE II

Maximum Temperature Due to Reaction Exotherm of Various LP-3/Epoxy Resin Combinations

(50 Gram Mass in a Paper Cup)

Thiokol LP-3	50	100	200	50	100	200
Bakelite ERL 3794	100	100	100	100	100	100
Tri-dimethylaminomethyl Phenol (DMP-303	10	10	10	—	—	—
Triethylene Tetramine (TET)	—	—	—	10	10	10
Cure Time, Minutes[b]	18	25	57	22	35	*a*
Maximum Temperature, °F	254	224	222	274	202	122

a Cure occurred sometime during the night.
b Ambient conditions were 76°F and 27% relative humidity.

Another technique for reducing the temperature due to exotherm is the use of heat conducting fillers, such as aluminum powder, to conduct the heat to the surface of the casting where it may be more readily dissipated. Electrical properties must be taken into account when these fillers are used, although Formo and Bolstad (10) report that a heat conducting casting compound heavily filled with aluminum powder had a thermal conductivity of 50 x 10^{-4} cal/sec./cm^2/°C/cm with a surprisingly high electrical resistivity of 500,000 megohms.

Frequently the encapsulated electronic and mechanical components are expensive and it thus becomes desirable to be able to re-enter the potted unit and salvage the components. This may sometimes be accomplished by

merely cutting the compound away. A special stripper is also available, which is marketed by the Turco Products Company under the name Turco 2822, which may be resorted to for the more complex embedments such as electrical connectors and the like. Similar materials are being placed on the market continuously.

The modified epoxy compounds are generally more difficult to remove. Where conditions permit, re-entry may be effected by heating the casting to 300°F. At this temperature the compound has the consistency of art-gum eraser and may be pried away from the components manually. There have also been a number of "solvents" or strippers placed on the market specifically for these compounds. These are listed in Table III with their suppliers. The action of these strippers is not by solution but appears to result from swelling the polymer network until it cracks under the internal strain. Tests on ½ inch cubes of a 1:1 LP-3/Epon 828 mixture cured with 10 parts by weight of triethylene tetramine per 100 parts of epoxy resins, indicated that even after two weeks immersion the amount of solution in these strippers was very small. However, after immersion overnight the test samples in all of the strippers listed had crumbled into tiny pieces making it easy to recover any embedded components.

TABLE III

Commercial Strippers for Polysulfide Polymer-Modified Epoxy Resin Systems

Stripper	Manufacturer	Amount of Solution after 1 Week[a]
Armstrong Stripper	Armstrong Products Co. Warsaw, Indiana	7%
Monastrip EP (Rho Solvent)	Mona Industries, Inc. Paterson, N. J.	2
De Solve #292	Ram Chemical Company Gardena, California	4
Octastrip 26 regular	Octagon Process, Inc. Staten Island, New York	8
Octastrip 26 special		4 grain[b]
Octastrip 31		3 grain[b]

a ½ inch cubes of 100/100/10 LP-3/Epon 828/TET completely immersed.
b Probably incomplete drying.

II. Dimensional Stability

Dimensional stability is particularly important in casting and embedment operations because of the delicate nature of the components frequently encountered. Where such components are found, two methods are available for protecting them: one is to match the coefficients of thermal expansion as closely as possible; the other is to use a formulation with a modulus low enough so that the strain is taken up by the plastic before the delicate components are stressed beyond their yield point. This applies during the conversion of the resin compound from liquid to solid as well as during temperature cycling. Shrinkage is a function of cure temperature. Thus, slow room temperature cures are favorable to low shrinkage.

The epoxy resins have volume shrinkage values which may run as high as 6 percent or higher during conversion from liquid to solid. Addition of LP-3 reduces this value to as little as 2 or 3 percent. The low shrinkage of the modified epoxy compounds can be better appreciated if one considers the applications of these materials in pattern shops where tolerances of a thousandth of an inch and better are specified, or where 180-line screen halftone engravings, one of the finest used in the printing industry, have been cast from a modified epoxy compound without loss of detail or dimension. Shrinkage can be further reduced by the incorporation of fillers.

Fillers are also important in adjusting the thermal expansion of the embedding resin to match that of the embedded components. Thermal expansion coefficients have been reduced almost threefold by the use of fillers. (9) Negative-coefficient fillers are available, such as Stupalith A-2410 (a lithia ceramic manufactured by the Stupakoff Ceramic and Manufacturing Company) which aid in counteracting the thermal expansion of the resins.

The true criterion of an effective casting compound is its ability to withstand severe temperature cycling without damaging delicate components or failing itself. Several LP-3/epoxy resin compounds were cycled between −55°C and + 105°C as specified (7,11) for Type B compounds, without failure. In these tests the lower temperature is maintained for ten minutes and the upper temperature for 30 minutes. The compound must withstand a minimum of ten cycles without failure to qualify. The compounds tested consisted of either 33%, 50%, or 67% LP-3 with Epon 828, and ten parts of curing agent (DMP-30 or TET) per 100 parts of epoxy resin. Unmodified epoxy resin failed this test. In another cycling test, an electrical circuit consisting of a flashlight bulb and battery and a glass mercury switch were potted in a cylinder of LP-3/Epon 828/TET in the ratio of 100/100/10. The total casting was five inches long and ⅞ inches in diameter. Several of these units went through six cycles totalling 296 hours, between -65°F and + 180°F without failure.

It has been reported that such properties as solvent resistance, electrical resistance at elevated temperatures, and dimensional stability are roughly related to the heat distortion temperature of the plastic. (10) Our laboratories are currently engaged in an intensive study of the heat distortion properties of polysulfide polymer-modified epoxy resins. Our preliminary data permit us to draw some general conclusions: with room temperature cures, the heat distortion properties of the epoxy resin are lowered only slightly by the addition of up to 40 parts of LP-3 to 100 parts of epoxy resin; the heat distortion properties improve with room temperature aging; the curing agent is one of the controlling factors in determining the heat distortion temperature; with room temperature cures, tri-dimethylaminomethyl phenol (DMP-30) is superior to triethylene tetramine (TET) as a curing agent giving good heat distortion properties. The most important finding was that the more flexible the sample, the lower the heat distortion temperature as determined by the standard ASTM (1) heat distortion test. In Table IV, some heat distortion temperatures of LP-3/Epon 828 systems are presented for two different curing agents at a maximum fiber stress of 264 psi.

TABLE IV

Some Heat Distortion Temperatures[a] of LP-3/Epon 828 Compositions at 264 PSI

Parts LP-3/100 Parts Epon 828	Temperature, °F 0	20	40	60	80
With DMP-30	141.5	139.7	137.0	133.2	122.0
With TET	132.7	122.0	113.9	106.5	92.7

a ASTM D648-45T

As heat distortion may be considered a measure of the loss of rigidity of a material at elevated temperatures, so may low temperature torsional measurements be considered as a measure of the loss in flexibility of a material at reduced temperatures. From low temperature tests, shear modulus, G, may be determined. Our test is a modification

of the ASTM Gehman Torsional Test (2) where gram weights replace the calibrated torsion wire. In the tests with the modified epoxy resins it was found that the aliphatic epoxies (Epon 562) gave better results than the aromatic (Epon 828). When a sample is cured with DMP-30, annealing the specimen for ½ hour at 300°F results in an extremely flexible material having a greatly improved low temperature torsional modulus. Increasing the amount of polysulfide polymer used to modify the epoxy resin also improves the torsional modulus. These effects are shown in Table V. The control samples, unannealed, were too stiff to test.

TABLE V

Low Temperature Torsional Properties of Some LP-3 Modified Epoxy Resin Systems

All specimens annealed ½ hour at 300°F

LP-3	100	0	50	100	200
Epon 828	100	—	—	—	—
Epon 562	—	100	100	100	100
DMP-30	10	10	10	10	10
Absolute Moduli					
G(rt psi)°F	366	437	344	244	126
G(5,000 psi)°F	+34	+17	+20	−11	−40
G(10,000 psi)°F	+26	+7	+8	−21	−47
G(20,000 psi)°F	+20	−3	−5	−34	−56

Because the Thiokol based compounds have a modulus low enough to absorb any strains developed in the cast unit, their dimensional stability is less important than it is for the modified epoxy resins. The dimensional stability of the Thiokol based compounds is superior to that of the modified epoxy compounds. Volume shrinkage during conversion from liquid to rubber is low, usually less than two percent. Shrinkage of the cured polymer while aging is less than ½ percent and here, too, may be further reduced by the proper selection of filler. Exemplifying the low shrinkage of these compounds is their use in dental impression compounds where dimensional requirements are considerably more demanding than in most electrical sealing applications.

The polysulfide polymer based compounds also have superior low temperature properties when unmodified. These are shown in Table VI.

TABLE VI

Low Temperature Torsional Properties of Some Polysulfide Polymer Compounds

LP-2	100	100	100
C-5 Paste[a]	15	15	—
GMF[b]	—	—	4
TiO_2	—	—	50
Sulfur	—	—	1
Absolute Moduli			
G(rt psi)°F	40	36	170
G(5,000 psi)°F	−73	−68	−62
G(10,000 psi)°F	−78	−73	−64
G(20,000 psi)°F	−85	−84	−68

a 50% lead dioxide, 45% dibutyl phthalate, 5% stearic acid.

b Para-quinone dioxime.

c Cured 1 hour at 158°F and sheet pressed out 10 minutes at 270°F.

III. Physical Protection

The physical protection encompasses the impact resistance of the compound, shock damping, mechanical strength in tension and compression, and the positioning and physical support of the components. Positioning, in some applications, may be a critical property. Javitz (14) illustrates this with a case history of an embedded torquemeter pickup assembly in which two electromagnetic sensing pickups were embedded in a precision-cast aluminum housing. The position of each pickup relative to the other had to remain constant under all conditions. Enough physical support had to be supplied by the compound to maintain positions constant during a finishing end-mill operation on the housing, compound, and pickups.

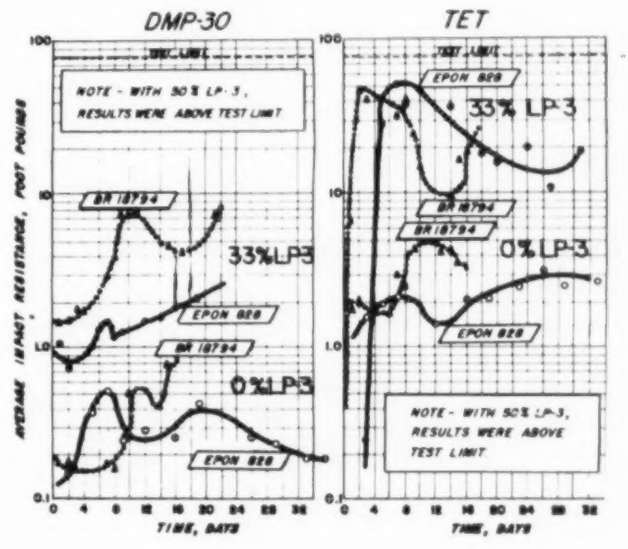
Frequently, modified epoxy compounds are called upon to fulfill such requirements and do so with considerable success.

Surprisingly, it has been found that rigid materials may offer better protection in some instances against mechanical shock to the components than a resilient material. This may be attributed to the existence of a "double shock" due to rebound of the components within the resilient compound. We evaluated rebound using the Bayshore Rebound resiliometer, which essentially involves dropping a centrally guided plummet weighing 31.6 grams from a height of 17 inches on a test sample (2 inches x 2 inches x ½ inch thick) and determining the maximum rebound on a scale calibrated 2.5 units to the centimeter. In tests using samples cured with triethylene tetramine, a 1:2 LP-3/ Epon 828 ratio had a rebound of 40 while a 1:1 ratio went only to 26. This is an indication of the increased shock damping that may be obtained with increased amounts of LP-3.

The polysulfide polymer-modified epoxy compounds have very high impact strengths, in contrast to the unmodified epoxy resins which are extremely brittle, and prone to shatter readily. In our laboratories, impact strength is determined directly in foot-pounds, by the falling ball method outlined in military and federal specifications, (7,11) with some minor modifications.

In Figure II, the effect of aging time on impact resistance is shown for some straight epoxy compounds and some LP-3-modified epoxy compounds containing 50 parts of the polysulfide polymer on 100 parts of epoxy resin. Samples containing 100 parts of polysulfide polymer could not be made to fail within the maximum limit of our test equipment which is 78 foot-pounds. Figure III illustrates the effect of post curing on samples cured with DMP-30. Here again, the 1:1 ratio of LP-3 to epoxy resin

Figure 2. Effect of Aging



was able to withstand the maximum impact of our equipment.

Additional impact data are shown in Tables VII through IX. The specimens in these tables were aged 5 to 7 days at room temperature before being tested. For all 1:1 ratios of LP-3 to epoxy resin, independent of the curing agent used, the maximum impact strength was observed. In some cases the inclusion of filler reduced the impact resistance. A comparison between the effects of different curing agents is possible. It appears that primary amines, which probably enter into the reaction, give higher impact strengths than tertiary amines.

Mechanical strength is less important in potting and embedment applications than it is in casting applications, since in the former case, mechanical protection is frequently afforded by a container of some sort. The use of a container permits LP-3 to epoxy resin ratios of 2:1 and higher. Such compositions are extremely soft and may have a tendency towards cold flow if unsupported. On the other hand, ratios of 1:1 and lower are self-supporting and do not require mechanical protection in most instances. The stress-strain properties of some filled and unfilled LP-3/Epon 828 formulations are shown in Tables VII through IX, both before and after heat aging for 72 hours at 212°F. Great difficulty was encountered in attempting to prepare samples of the unmodified epoxy samples and run the tests because of the extreme brittleness of these materials. The data for the unmodified epoxy resins are thus not shown; this information is available elsewhere. In these tables, the increase in tensile strength with time is shown for the 1:3 ratios of LP-3 to Epon 828. For the other ratios, the effects of two fillers are shown: AFD filler, an aluminum (silicate) flake dispersion manufactured by the Metals Disintegrating Company, Elizabeth, New Jersey, and OMYA BSH-30 (Blanc Special Hydrophobe), a surface-coated extra-fine calcium carbonate manufactured by Pluess-Staufer of New York, N. Y. In most instances, the tensile strength is reduced by these non-reinforcing fillers.

Tensile tests were run according to ASTM methods D412-51T for rubber and D638-52T for plastics, depending on the hardness of the specimen. In all cases, the samples were died out using Die C specified for rubber samples. Tests were run in duplicate on a Type TT-C Instron Tensile Tester (Instron Engineering Corp., Quincy, Massachusetts). The crosshead speed of the test unit was varied, depending on the Shore D Durometer hardness of the test specimen. The scheme generally followed was to use a speed of twenty inches per minute if the hardness was below 30; two inches per minute when the hardness was between 30 and 45; and 0.2 inches per minute for hardnesses above 45. Jaw separation speed has an extreme effect on the test results.

The rubbery Thiokol based compounds have, of course, entirely different mechanical properties than the modified epoxy resins. Impact is less of a problem because these materials can absorb considerably larger amounts of impact and vibrational energy. Tensile strengths are low, usually being in the range of 1,000 psi or less; elongations, on the other hand, are high, in some cases, as high as 1,000 percent.

IV. Electrical Protection

In addition to mechanical protection, the electrical protection afforded by these casting compounds results in great economies in manufacture and maintenance, and permit greater flexibility in design. The polysulfide polymer, and the modified epoxy resin compounds have intermediate electrical properties which permit their use in all but high voltage applications, although there has even been a case reported (3) where an LP-3-modified epoxy resin cable pothead was tested under water at 50°F and withstood up to 15,000 volts. Some dielectric strength data from the same source are presented in Table X for LP-3-modified epoxy resin systems.

The addition of certain plasticizers may raise the dielectric strength considerably. A case has been reported (15) in which a dielectric strength of 1250 volts/mil were obtained in a single test for the following formulation:

ERL 2795	100 parts by weight
LP-3	50
HB-40	70
Triethylene tetramine	15

The test sheet was cloudy indicating a certain amount of incompatibility with this amount of plasticizer. This composition was found to have a dielectric constant of 4.8 and a dissipation factor of 0.046. Plasticizer HB-40 is a partially hydrogenated mixture of isomeric terphenyls manufactured by the Monsanto Chemical Company. All dielectric strength tests were run according to ASTM method D149-44 by the step procedure.

In Tables VII through IX other electrical properties are given for several filled and unfilled LP-3/Epon 828 compounds. These fillers were not chosen for their electrical properties and actually are detrimental to them. Heat also has a detrimental effect on the electrical properties. Increased amounts of LP-3 tend to degrade the electrical properties, but only slightly. These compounds are unsatisfactory for high frequency applications because dielectric constants less than 2 and loss factors less than 0.001 have not been obtained with them. However, for normal frequencies they are perfectly satisfactory.

Although the data have not been shown, it was found that the LP-3/epoxy resin systems cured with meta-phenylenediamine have superior electrical properties than with the other agents shown in the tables. The meta-phenylenediamine requires a heat cure; four hours at 180°F was found to be satisfactory. With this cure, the effects of fillers, temperature, and LP-3 concentration were found to be almost negligible. The dielectric constant was between 3 and 6; the dissipation factor varied between 0.01 and 0.04; volume resistivity varied between 10^{13} and 10^{14} ohm-centimeters at 80°F and was constant at 10^{11} at 160°F over the entire range of LP-3 concentrations. The stress-strain properties were correspondingly high, particularly at the higher LP-3 concentrations, although the impact resistance was inferior to that of the other agents. Heat distortion properties are very high for unmodified epoxy resin with meta-phenylenediamine but inferior when the epoxy resin is modified with polysulfide polymer.

It is sometimes desirable to be able to put the components that are being potted into immediate service, even before the encapsulating resin has had an opportunity to cure. An example of this would be in a cable splice in the field. It thus becomes desirable to know the electrical properties of the liquid resins as they are being converted to the cured solid. In Figure IV, the dielectric constant and dissipation factor are plotted for a 1:1 LP-3/Epon 828 mixture with 10 parts of DMP-30 per 100 parts of epoxy resin as the curing agent, as a function of time, beginning at the moment of initial mixing and continuing through the gel and cure stages up to six days of post-

TABLE VII

Mechanical and Electrical Properties of Some LP-3/Epon 828 Formulations Cured with DMP-30

Ratio LP-3/Epon 828	1/3	1/3	1/2	1/2	1/2	1/1	1/1	1/1
Formulation								
Epon 828	100	100	100	100	100	100	100	100
LP-3	33	33	50	50	50	100	100	100
DMP-30	10	10	10	10	10	10	10	10
AFD Filler	—	—	—	50	—	—	75	—
OMYA BSH-30	—	—	—	—	50	—	—	75
Stress Strain Properties								
Days Aging @ R. T.	5	26	5	5	5	5	5	5
Crosshead Speed, In./Min.	0.2	0.2	0.2	0.2	0.2	2.0	2.0	2.0
Original Tensile Strength, psi	6100	7900	5100	4400	4300	950	800	1450
Elongation, %	70	13	16	22	12	71	56	35
Shore D Durometer Hardness	70	82	60	83	79	40	52	60
Heat-aged Tensile Strength	8500	—	5600	4000	3700	425	700	610
Elongation, %	18	—	28	22	15	83	69	86
Shore D Durometer Hardness	70	—	70	81	76	30	42	39
Impact Strength								
Days Aging @ R. T.	5	—	5	6	6	5	6	6
Shore D Durometer Hardness	85	—	85	85	85	71	75	65
Average Impact Strength, ft. - lbs.	2.5	—	14.7	8.3	24.8	>78.2	61.2	28.0
Electrical Properties								
Dielectric Constant @ 1 Kc								
80°F	4.25	5.15	5.25	4.80	5.45	5.64	5.59	5.96
160°F	4.55	—	6.50	5.64	6.42	7.90	7.85	8.60
Dissipation Factor @ 1 Kc								
80°F	0.005	0.011	0.014	0.011	0.008	0.018	0.016	0.016
160°F	0.024	—	0.093	0.070	0.066	0.279	0.595	0.339
Volume Resistivity, ohm-cm.								
80°F	5.6×10^{11}	4.7×10^{13}	3.3×10^{11}	5.8×10^{13}	3.8×10^{11}	7.7×10^{11}	6.8×10^{11}	5.6×10^{11}
160°F	1.1×10^{11}	—	1.4×10^{10}	2.2×10^{11}	1.4×10^{11}	4.0×10^{10}	6.4×10^{9}	1.8×10^{10}

TABLE VIII

Mechanical and Electrical Properties of Some LP-3/Epon 828 Formulations Cured with TET

Ratio LP-3/Epon 828	1/3	1/3	1/3	1/2	1/2	1/2	1/1	1/1	1/1
Formulation									
Epon 828	100	100	100	100	100	100	100	100	100
LP-3	33	33	33	50	50	50	100	100	100
TET	10	10	10	10	10	10	10	10	10
AFD Filler	—	—	—	—	50	—	—	75	—
OMYA BSH-30	—	—	—	—	—	50	—	—	75
Stress Strain Properties									
Days Aging @ R. T.	5	10	26	5	5	5	5	5	5
Crosshead Speed, In./Min.	0.2	0.2	0.2	0.2	0.2	0.2	2.0	2.0	2.0
Original Tensile Strength, psi	1500	4700	6400	1300	1700	1900	800	900	760
Elongation, %	45	20	14	68	25	24	73	48	46
Shore D Durometer Hardness	83	80	83	50	71	72	30	47	47
Heat-aged Tensile Strength, psi	7800			3300	3200	3000	1200	800	900
Elongation, %	15	—	—	32	21	14	53	35	40
Shore D Durometer Hardness	80	—	—	60	72	76	45	57	49
Impact Strength									
Days Aging @ R. T.	5	—	—	5	6	6	5	6	6
Shore D Durometer Hardness	81	—	—	75	75	75	37	55	52
Average Impact Strength, ft.-lbs.	28.2	—	—	49.8	29.8	22.2	>78.2	50.0	>78.2
Electrical Properties									
Dielectric Constant @ 1 Kc									
80°F	5.43	—	3.18	6.05	6.05	6.01	5.92	6.19	4.89
160°F	8.65	—	—	8.45	8.55	5.34	7.75	7.64	7.45
Dissipation Factor @ 1 Kc									
80°F	0.030	—	0.015	0.026	0.038	0.013	0.061	0.048	0.076
160°F	0.224	—	—	0.261	0.431	0.264	0.238	0.352	0.340
Volume Resistivity, ohm-cm									
80°F	1.8×10^{11}	—	8.9×10^{11}	6.0×10^{13}	3.5×10^{11}	4.4×10^{11}	8.0×10^{10}	1.2×10^{11}	1.9×10^{10}
160°F	6.3×10^{10}	—	—	4.2×10^{10}	8.7×10^{8}	3.0×10^{8}	3.3×10^{10}	1.1×10^{10}	1.2×10^{9}

TABLE IX

Mechanical and Electrical Properties of Some LP-3/Epon 828 Formulations Cured with DET (Diethylene Triamine)

Ratio LP-3/Epon 828	1/3	1/2	1/2	1/2	1/1	1/1	1/1
Formulation							
Epon 828	100	100	100	100	100	100	100
LP-3	33	50	50	50	100	100	100
DET	12	12	12	12	12	12	12
AFD Filler	—	—	50	—	—	75	—
OMYA BSH-30	—	—	—	50	—	—	75
Stress-Strain Properties							
Days Aging @ R. T.	5	5	5	5	5	5	5
Crosshead Speed, In./Min.	0.2	0.2	0.2	0.2	2.0	2.0	2.0
Original Tensile Strength, psi	5400	1250	2100	2300	830	600	450
Elongation, %	19		27	16	79	93	110
Shore D Durometer Hardness	50	60	71	71	35	36	22
Heat-aged Tensile Strength, psi	6600	4800	2700	2700	1100	800	700
Elongation, %	18	20	27	12	80	70	140
Shore D Durometer Hardness	60	60	75	73	40	51	37
Impact Strength							
Days Aging at R. T.	5	5	7	7	5	7	7
Shore D Durometer Hardness	82	74	70	70	34	30	26
Average Impact Strength, ft.-lbs.	37.6	40.7	43.9	18.7	>78.2	>78.2	>78.2
Electrical Properties							
Dielectric Constant @ 1 Kc							
80°F	5.35	5.24	6.09	5.99	6.35	6.75	7.21
160°F	6.80	4.82	8.05	7.55	7.64	9.04	8.75
Dissipation Factor @ 1 Kc							
80°F	0.015	0.018	0.034	0.046	0.034	0.049	0.067
160°F	0.095	0.121	0.169	0.166	0.228	0.570	0.555
Volume Resistivity, ohm-cm							
80°F	6.7×10^{13}	2.9×10^{13}	1.7×10^{13}	3.2×10^{11}	1.9×10^{11}	1.1×10^{11}	7.4×10^{9}
160°F	1.6×10^{11}	4.6×10^{11}	1.8×10^{11}	2.4×10^{9}	2.0×10^{11}	5.0×10^{8}	1.1×10^{10}

Figure 3.

Heat-Aged Impact Resistance (DMP-30 Catalyst)

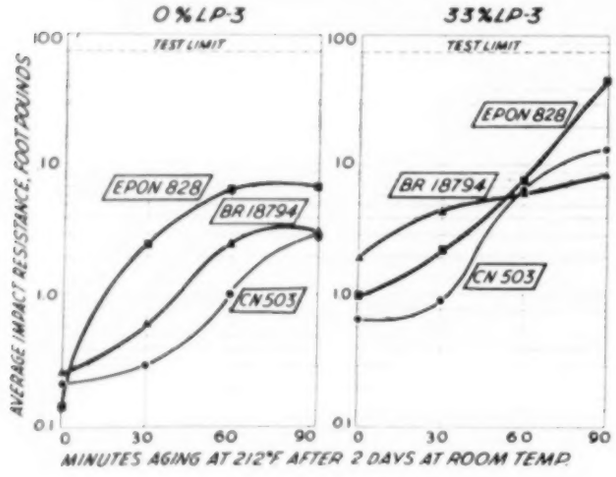
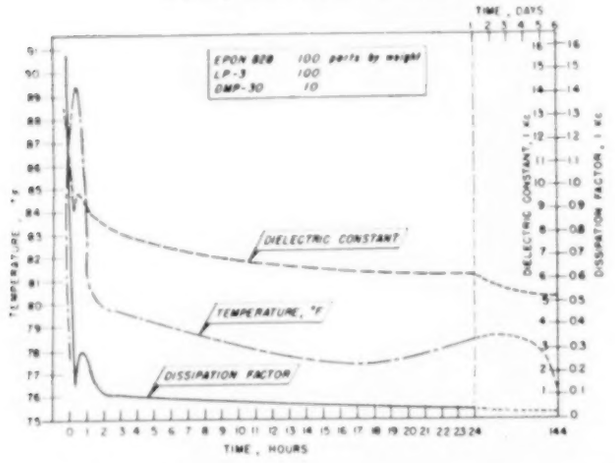


Figure 4.

Electrical Properties of LP-3/Epoxy Resin Compound During Conversion to Solid



curing. The temperature, measured at the center of the mass with a thermocouple, is also shown. Approximately 30 grams of material were contained in the brass test cell. Twenty-five minutes after combining the reactants, a minimum point in the electrical measurements corresponding to a maximum point in the exotherm temperatures was observed. Since the electrical properties are degraded at elevated temperatures, it may be assumed that the electrical property curves, if corrected for temperature, would be curves of a monotonically decreasing function without minimum or maximum points.

It appears that the electrical properties fall into a useful range three to four hours after mixing this particular formulation, although apparent cure (rigid, nontacky compound) was observed after 90 minutes; other catalysts and ratios require more or less time.

The volume resistivities of the liquid resins are only marginal, but they may be satisfactory for immediate ser-

(Continued on Page 59)

TABLE X

Dielectric Strength of Some LP-3/Epoxy Resin Compounds

LP-3	100	100	100	100
ERL 3794	100	200	—	—
Epon 828	—	—	100	200
DMP-30	10	20	10	20
Breakdown Kv	15.6	18.7	18.7	22.5
Thickness at Failure, mils	51	65	51	73
Dielectric Strength, volts/mil	306	288	367	308

TABLE XI

Electrical Properties of Some Filled LP-32 Compounds

LP-32	100	100	100
Sulfur	0.2	0.2	0.2
C-5 Paste	15	15	15
Lithopone (Albalith)	50	—	—
Zinc Sulfide-800 (Kryptone)	—	40	—
Carbon Black (Sterling MT)	—	—	30
Shore A Durometer Hardness	45	42	45
Dielectric Constant at 1 Kc	7.7	7.5	14.0
Dissipation Factor at 1 Kc	0.003	0.003	0.20
Volume Resistivity, ohm-cm.	8.4×10^{11}	4.3×10^{11}	5×10^{11}

TABLE XII

Chemical and Solvent Resistance of LP-3/Epoxy Resin Systems Cured with DMP-30

Percent Volume Swell after 30 days Immersion at 80°F

LP-3 Concentration, %	33			50			67		
Epoxy Resin	Epon 828	ERL 3794	Ciba 6020	Epon 828	ERL 3794	Ciba 6020	Epon 828	ERL 3794	Ciba 6020
Hydrochloric Acid, 10%	2	2	2	4	4	6	—	27	—
Hydrochloric Acid, 30%	2*	2*	—	11*	8*	—	—	55*	—
Sulfuric Acid, 20%	2	2	2	4	3	5	—	12	—
Sulfuric Acid, 60%	11	11	—	*	*	—	—	—	—
Nitric Acid, 20%	*	*	—	*	8	—	—	*	—
Nitric Acid, 60%	*	*	—	*	*	—	—	—	—
Sodium Hydroxide, 10%	-1	2	2	2	7	2	—	6	—
Sodium Hydroxide, 50%	1	0	-1	-1	0	2	—	0	—
Ammonium Hydroxide, conc.	3	3	11	7	3	33	—	7	—
Formaldehyde, 37%	3	4	—	9	5	—	—	12	—
Dibutyl Phthalate	1	1	—	9	4	—	—	4	—
Sodium Carbonate, sat'd. sol'n.	1	1	1	2	2	3	—	2	—
Aluminum Sulfate, sat'd. sol'n.	2	2	1	2	2	2	—	2	—
Sodium Chloride, sat'd. sol'n.	0	2	1	1	1	4	—	2	—
SR-6 (aromatic aviation gas)	2	1	0	2	0	2	4	8	6
SR-10 (aviation gas)	-2	-1	-2	-2	-1	0	-20	0	0
Benzene	38	1	23	32	8	32	*	*	89
Xylene	2	1	0	8	2	10	-7	4	14
Toluene	2	1	6	20	6	4	17	1	33
Acetone	29	25*	13	13	24	21	*	*	5
Methyl Ethyl Ketone	33	26*	14*	18	7	18	*	*	31
Methyl Isobutyl Ketone	2	1	0	12	4	12	*	12	10
Carbon Tetrachloride	2	0	0	12	8	18	45	17	40
Ethyl Acetate	26	2	20*	18	12	25*	2	3	50
Ethyl Alcohol, denatured, (Ponsolve)	1	0	8	7	9	12	3	2	8
Water	2	0	2	4	4	6	-1	4	5

*sample failed

Importance of Engineering Talent

In the Operation of a Plastic Custom Molding Company

By H. S. Ruekberg

Continental Can Company
Millsplastic Division

When I was requested to give a paper on the subject of "The Importance of Engineering Talent in the Operation of a Plastic Custom Molding Company", I contemplated that an interesting way to begin would be to quote a dictionary definition of an Engineer, anticipating that the dictionary would give an extremely glowing definition of a superior being, who knows all there is to know about the physical sciences—and who is capable of putting his knowledge to work—thereby solving any and all problems that may arise. Such a definition would preclude any further talking on my part. I could quote the dictionary and make way for the next speaker.

With this in mind, I searched thru every dictionary the local library could produce, but found no such laudable description. Consequently, I cannot begin (and end) my talk the way I so optimistically dreamed—instead I must start with our own definition of an Engineer.

I should like to make it clear at the outset that not all qualified engineers have necessarily received a formal college engineering education. Some men have achieved success in their field because they possess great intuitive talent for engineering and have obtained the qualifications of an engineer by self-education and years of experience. However, for the sake of simplicity, I would like to use the college trained engineer for our definition.

Therefore, let us say that our engineer is a man who has graduated from an engineering school and has had enough practical experience outside of school to know how to apply his formal education. It is interesting to note that when a man graduates from an engineering school, he receives a B.S. Degree. It requires a minimum of 2 years engineering work in industry before he can receive his B.S. M.E. Degree (that is Bachelor of Science in Mechanical Engineering).

As a result of college training, a graduate engineer should have the following qualifications:

1. A vast reservoir of technical information, encompassing the physical sciences, economics, labor relations, and business organization.
2. The ability to put this knowledge to use.
3. The technique of using a scientific approach in attacking a problem.
4. The social graces, so that he may meet and get along with the people in industry with whom he must work.

Custom Molding Plant

We all understand that a custom molding plant is a manufacturing plant that specializes in the molding of products for other industries or businesses.

Let us follow the path of a hypothetical job produced by a custom molder. The first step is to sell the job. This means that the salesman must be capable of obtaining the deal about plastics, but also a considerable amount about the customer's industry.

In many cases, the article to be molded has not been completely designed when the molding salesman is called in. If the Salesman can aid the customer in the design of his product, he not only wins the gratitude of the customer and places himself in a good position to obtain the order, but by influencing the design with a sympathetic eye toward molding problems, he clears the way for successful molding production.

In some cases, where the customer calls the molder in to quote on a part that has already been designed, the molder can put himself in a good competitive position by suggesting modifications that will make the piece more economical to mold. Many times thinning down a wall, removing an undercut, substituting a rib for a heavy boss, will change the cost-picture of a product without reducing its quality or utility. Most Molders know that heavy walls, undercuts, and the like increase product costs, but usually it takes some clever engineering to eliminate these hazards.

We have examined a case where a product is partially designed at the time the molding salesman appears on the scene and another case where the part is completely designed. Now let us look at an instance where the potential customer has nothing on paper, but comes to the molder with an "idea" that he wants made out of plastic. This may sound funny, but we cannot afford to ignore **this** customer. Millions of dollars worth of plastic products are produced every year for these men who come to the molder with an "idea", plus two other important things; the money to produce the item and the ability to sell.

The molder **without** good engineering talent loses this vast potential market. On the other hand, the molder who wants this business has the responsibility of engineering and designing such a variety of products that it staggers

(Presented at the SPI Midwest Plastics Conference, April 27.)

the imagination. His engineering staff may be called upon to design optical instruments, musical instruments, lighting fixtures, electrical toys, or other specialty products. An engineer is not expected to have all the information for these problems at his fingertips, but a **good** engineer will always know which handbook to open to obtain it.

We must keep in mind that it is the salesman who is in direct contact with the customer. He, therefore, should be able to anticipate the questions that his estimators and tool designers may want answered. It makes a good impression on a customer when a salesman, in discussing a molding job, asks intelligent questions and gets all of the pertinent information regarding the job, such as location of parting lines, gate marks, weld marks, sharp or fileted corners, tolerances, and draft. It is conceivable that in certain applications, if flash is at right angles to a core pin, it will cause no trouble as far as the function of a part is concerned, but flash cannot be tolerated in the same hole if the flash is parallel to the pin. If the salesman can get all this information from the customer, he will make the job of estimating costs much easier. He will also have recommendation on the design of the mold (such as should core pins shut off by telescoping or butting?). Lastly, he will make sure that the customer will know exactly what he is going to get.

I have seen case after case where a salesman has asked the purchasing agent questions of such nature that the purchasing agent has had to call in his design engineer for the answers. This meeting between the design engineer and the plastics sales engineer resulted in an improved design for the customer. But more important, the design engineer on any future jobs requiring plastics would call in the plastics sales engineer for consultation, thus putting the salesman in a superior position for obtaining new custom jobs for his plant.

It, therefore, follows that engineering plays an important role in selling a custom molded job.

Before the contract can be secured, it is necessary to ascertain what it will cost to produce an item. Here again we must rely on an engineer. A large percentage of the cost of a plastic casting is in the material. Consequently, it is mandatory that the exact weight be calculated usually with only a blueprint to go by. It would be interesting if we could check back and see how many contracts were lost because the calculated weight of the product was too high. I might point out that it is even more painful to obtain a contract and then find that the calculated weight was too low.

The next step is to determine the number of mold cavities to recommend for each job. To do this properly, the cost per cavity must be plotted against the quantity of pieces to be produced and the effect of the different size molds on the molding cost. Here again the chances of obtaining a contract hinge upon the accurate and intelligent calculation of the size of a mold.

The other factors going into the determination of a piece part price may also be made more tempting to the customer by proper engineering. Calculating the price of a mold takes another ticklish bit of engineering.

Further profits can be obtained if there is a plant industrial engineer, who will plan the work, so that after molding, the product will be finished, inspected, packed and out of the door with a minimum of handling.

New Techniques

In the past few years, many radical changes in injection molding techniques have been introduced. Some of these are: pin point gating, hot runner molding, 3-plate molding, multiple nozzle molding, automatic degating within the mold. The press manufacturers have given us low pressure closing to expedite fully automatic molding. Materials have improved making it possible to mold thinner sections than ever before.

One might think that all of these innovations make it easier for the custom molder. Let us see if this is the case. Before these changes were introduced, a custom molder upon receiving an order, proceeded to tool along conventional tried and true lines. He had a good idea of his runner and gate sizes; he was also quite sure of what his mold shrinkage would be. He knew that there would be at least one operator at each press.

Jobs of All Descriptions

Keeping in mind that a custom molder receives jobs of all descriptions, sizes and materials, let us look at just a few of the questions that he now must answer:

Should I use hot runners, multiple nozzles, 3-plate mold, or conventional runners and gates?

If I use a hot runner, will the difference due to thermal expansion between the runner plate and the core plate cause any problem in concentricity?

If I use a hot runner mold, will the casting shrink the same amount as it did when a 3-plate mold was used?

If I run the job fully automatic, how will I handle the parts after they accumulate? When and how will they be inspected?

Am I sure that I will not abuse the mold by fully automatic operation?

Where do we get the answers? The machinery manufacturers and the material suppliers have their experts, who are willing to give advice whenever called upon, but we must bear in mind that in custom molding every job is a little different and we must be able to face our own problems as they present themselves.

It is up to the engineer to evaluate all of the new methods and to thoroughly understand them. He must, most of all, know what their limitations are and what new problems they will introduce, and he must be capable of overcoming these problems. It is up to him to decide which technique should be used for each specific job.

Another area in which engineering is important is in the maintenance of machinery. A molding plant should have a plant engineer, who should be in charge of keeping all molding presses and relevant equipment in top-notch shape. If machines are not maintained properly, it will result in falling behind in schedules, poor quality production and expensive repair bills. A preventative maintenance program should be set up covering the proper lubrication of machinery, maintenance of pumps and valves, changing or cleaning of the hydraulic oil and checking over the press for sticky timers and other electrical equipment. A program of this type will preclude expensive maintenance that will eventually occur if the proper preventative steps are not taken.

It is my opinion that engineering talent is more important now than ever before in the operation of any custom molding plant. Many customers are now using so many plastic products that they are tempted to do their own molding. We must show them that thru our "know-how", we can give them better service and quality than they can produce themselves and at a lower cost. Labor costs are increasing. The custom molder is trying to hold his prices down for his customers. The only way this can be accomplished is by more automatic operations, reductions in handling cost, more production per machine, and a general increase in efficiency. We are looking to our engineers to continue to guide us along these paths.

KEL-F® PLASTIC PRICE REDUCTION

INDUSTRY'S MOST "VALUABLE" PLASTIC NOW COSTS LESS THAN EVER

Starting At $6.00 lb. For Low Density Grades In Volume

If, because of the cost factor, you have to forego the advantages of fluorocarbon plastics and substitute other materials—then the new lower price for KEL-F Plastic should be welcome news!

This hard, dense thermoplastic offers a combination of properties unobtainable in any other material. It is readily moldable. It has extreme resistance to chemical attack, heat and cold. It possesses excellent dielectric properties.

All these characteristics, plus high compressive strength, zero-moisture absorption, non-wettability and abrasion resistance, place KEL-F Resins high on the list of wanted plastics . . . in the chemical, electrical, equipment and aviation fields.

If you haven't already, now, *more than ever*, is the time to investigate KEL-F Plastic. Perhaps it can help *you* create better products, meet higher performance specifications, or prolong equipment life.

TECHNICAL SERVICE

As always, Kellogg—with its staff of research chemists and experienced technical service team—stands ready to assist you. The facilities of our Customer Service Laboratories are available for the investigation of problems related to the applications and use of KEL-F fluorocarbon materials in your products.

For further information and a list of the new prices for KEL-F molding powders, write: The M. W. Kellogg Company, Chemical Manufacturing Division, P. O. Box 469, Jersey City 3, N. J.

KELLOGG

THE M. W. KELLOGG COMPANY

SUBSIDIARY OF PULLMAN INCORPORATED

® KEL-F is the registered trademark of The M. W. Kellogg Company for its fluorocarbon products.

STABILITY of VINYL WINDOWS

FIDELITY in VINYL RECORDS

are assured when you manufacture with Enjay Oxo Alcohols

Vinyl rear windows in convertibles or vinyl phonograph records . . . and a large number of today's other wonderful, new vinyl products are made from plasticizers using Enjay Oxo Alcohols.

Whatever your product, you can always count on Enjay—the world's largest supplier of Oxo Alcohols—for uniform high quality.

The Enjay Laboratories are at your service to help solve technical problems related to the application or use of *any* Enjay product.

For detailed information, write or phone today!

Enjay offers a diversified line of petrochemicals for industry:
HIGHER OXO ALCOHOLS (Isooctyl Alcohol, Decyl Alcohol, Tridecyl Alcohol); LOWER ALCOHOLS (Isopropyl Alcohol, Ethyl Alcohol, Secondary Butyl Alcohol); and a varied line of OLEFINS AND DIOLEFINS, AROMATICS, KETONES AND SOLVENTS.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., **15 WEST 51st ST., NEW YORK 19, N. Y.** Other Offices: Akron, Boston, Chicago, Los Angeles, Tulsa

Action— By Your National Organization

"The objects of the Society shall be to promote in all lawful ways the Arts, Sciences, and Engineering Practices and Standards connected with the utilization of plastics."

An Open Letter to SPE Section Presidents

August 20, 1956

You are a mighty important man in this SPE organization. As President of your local Section you have been given an honor as well as a responsibility. I suppose that by this time you are beginning to check out your plans for the Fall season and are beginning to realize that some work is involved.

I can say that from contacts I have had all summer with many SPE members that this promises to be the most active season our organization has thus far experienced.

First, all sections are completing plans for local meetings designed to be of more help to the membership. Some sections have used questionnaires to get answers to questions of programs and activities.

Several sections are actively planning Regional Technical Conferences:

Plastic Pipe Symposium, Montreal, Sept. 20
Isocyanate Symposium, Minneapolis, Oct. 23
Epoxy Symposium, Los Angeles, November 16

Other plans are underway for additional special subject meetings. If your section is interested in sponsoring such a meeting notify your councilman and ask him to clear the date with the National Meetings Committee.

Plans for the 13th Annual National Technical Conference in St. Louis are well along. Get your group together to support this meeting by attending it.

One SPE book is at the publishers and the second is almost ready to be turned over to them. These books, Quality Control for Plastics Engineers and Injection Molding will be the first two in a proposed series of engineering volumes dealing with plastics problems.

As you know, we secured the services of a new Executive Secretary this year, Jas. R. Davidson. We are confident of great accomplishments under his general direction.

Our roster should bear the names of many new members this fall as a result of work by membership and new section committees.

We can all look forward to a big year if the kind of enthusiastic support I have witnessed continues to spread throughout the local sections. I will appreciate your sparking the enthusiasm of your section. All who have contributed time and effort toward making SPE click have gained much more than personal satisfaction.

Furthermore I would appreciate hearing from you at any time with comments or suggestions. The ideas for improving and expanding SPE must come from individuals like yourself who think.

Best wishes for the best season yet!

Yours truly,

Jerome Formo,
President SPE

Plastics Meetings and Programs

Isocyanate Symposium

——UPPER MIDWEST——

In line with the National S. P. E. policy to have regional conferences on highly specialized technical subjects, the Upper Midwest section of the S. P. E. is sponsoring an "Isocyanate Symposium" on Tuesday, October 23, 1956.

Cort Platt of Remington Rand Univac, as general chairman; and Wm. Jarvey, of Archer Daniels Midland Co. as program chairman extend an invitation to all members of the S.P.E. to attend this interesting and timely symposium.

Isocyanate based polymers are a relatively new class of chemicals becoming of increased commercial interest in protective coatings, foams for comfort and household use, crash pads or safety devices in automobiles, adhesives, potting compounds, and rubber polymers or so called 100,000 mile tires.

The program scheduled at the Curtis Hotel in Minneapolis, Minnesota is as follows:

9:00 A.M. "Introduction and History of Isocyanates"
C. L. Wilson, Faculty Member, University of Notre Dame
"New Surface Coatings Based Upon Diisocyanates"
M. E. Bailey, Manager Application Research-Isocyanates National Aniline Division of Allied Chemical and Dye, Buffalo, N. Y.
"Urethane Coatings and Adhesives"
George A. Hudson, Development Department, Mobay Chemical, St. Louis, Mo.
Question and Answer Period

12:00 Noon Lunch

1:30 P.M. "Non Scorching Polyurethane Elastomers"
E. E. Gruber, O. C. Keplinger, Research Department General Tire and Rubber Company, Akron, Ohio
"Effects of Foaming Catalysts on Hydrolysis Aging of Urethane Foams"
Joseph Winkler, Chief Chemist, American Collo Corporation, Ridgefield, N. J.
"Effects of Toluene Diisocyanate Isomer Ratios in Polyurethane Foams"
E. E. Gruber, G. T. Gmitter, Research Department General Tire and Rubber Company, Akron, Ohio
"Use & Applications of Isocyanate Foams"
C. Bradford Muzzy, Plastics Division, Nopco Chemical Company, Harrison, N. J.
Question and Answer Period

Advanced Reservations can be sent c/o Mrs. Luther Bolstad, 3857 Brookview Drive, Minneapolis 26, Minnesota.

Registration Fee $3.00

Indicate the number of hotel accommodations needed for the nights of Monday October 22, and Tuesday October 23.

Preprints of the talks available free to registrants; moderate charge to non-registrants.

Armed Services Packaging Meet

The Department of the Air Force, with the cooperation of the Department of the Army, the Department of the Navy, the Department of Commerce, and the National Security Industrial Association, is sponsoring the Second Joint Military-Industry Packaging and Materials Handling Symposium in Washington on October 9, 10, and 11, 1956. Herewith is a copy of a release dated July 25, 1956, from the Air Force, giving further information about the program.

Programs and registration cards which will be available about August 15, 1956 may be obtained from:

Containers and Packaging Division
Business and Defense Services Administration
U. S. Department of Commerce
Washington 25, D. C.

The Symposium, being coordinated for the military by the Air Force, is the second in a series designed to familiarize defense and industrial leaders with current developments in these two critical fields of mutual interest. The Army, Navy, Department of Commerce, and the National Security Industrial Association are assisting the Air Force in the development of the program.

The three-day program has been designed to provide a maximum of information in specific areas of interest. Widely diversified panels on packaging and materials handling will be held separately over the period. Arrangements have been made to include recognized authorities in each field as panel leaders and members throughout the Symposium.

The Symposium will be open to the public.

Advance registration is desirable, however late registrations may be accomplished between the hours of 0800 and 1000 at the DEPARTMENTAL AUDITORIUM on Constitution Avenue between 12th and 14th Streets, N.W.

Coatings Symposium

A coatings symposium for the West Coast protective coatings industry will be conducted by Hercules Powder Company, in Los Angeles, September 11-14.

The symposium is endorsed by the

Los Angeles Paint and Varnish Production Club and the Los Angeles Paint, Varnish and Lacquer Association. It is designed to provide the West Coast protective coatings industry with up-to-date information on the important fundamentals of lacquer technology, as well as new developments in a wide variety of protective coatings.

The symposium has been divided into two sections. The first two days will be devoted to discussions of fast-drying industrial finishes based on nitrocellulose. The final two days will include discussions about chlorinated rubber and silicone finishes.

All sessions of the symposium will be held in Los Angeles' Roger Young Auditorium. Industry representatives can either register on September 11, at Roger Young Auditorium, or make advance registrations at Hercules' Los Angeles sales office, 3460 Wilshire Boulevard. There is no charge for registration, or for attending the conference.

Wisconsin Plastics Institute

Plastics: Application In Product Design And Development

A Plastics Institute will be held at the University of Wisconsin on October 18-19. The tentative schedule is:

Thursday, October 18, 1956

9:15—Importance of Part Design, R. J. Jablonski, Supv. of Cabinet Engr. Refrigeration Dept., Hotpoint.

10:45—Selecting the Proper Material. Suggested Speaker: R. R. Moyer, Manager, Styrene Tech. Service, Monsanto.

12:00—Lunch.

1:30—Selection of Molding Method. Suggested Speaker: Carl Massopust, Director, Research & Development, Plastics Div., General American Trans. Co.

3:00 — Engineering of Purchased Molds. Suggested Speaker: John Andras, Chief Engineer, Major Mold and Die.

4:15—Adjourn until 6:30 P.M.

6:30—Dinner Meeting. "Correlation of Physical Tests With End Use." Suggested Speaker: R. A. McCarthy, Technical Service, Monsanto.

FRIDAY, October 19, 1956

9:00—Considerations in Choosing Molder. Suggested Speaker: C. O. Epperson, Mgr. of Purchasing, Refrigeration Dept., Hotpoint.

10:15—Break

10:30—Relation of Molder to Design Engineer and/or End User. Suggested Speaker: Harold Hulterstrum, Chief Engr., Flambeau Plastics.

11:45—Lunch.

1:15 to 3:15 — Panel Discussion on Questions Relating to All Subjects Discussed at Institute. Suggested Members: Mr. Jablonski, Mr. Moyer, Mr. Andras, Mr. Massopust, Mr. Hulterstrum.

Complete programs will be available in the middle of September. Write to Ralph D. Smith, Institute Coordinator, U. of Wisconsin, Extension Div., Dept. of Engineering, Madison 6, Wisconsin.

15 Years of Plastics Progress

"Fifteen Years of Plastics Progress" is the theme of The Society of Plastics Engineers' 14th Annual National Technical Conference which will be held January 16, 17, 18, 1957 at the Sheraton-Jefferson Hotel in St. Louis.

Tentatively scheduled are almost eighty papers. Mr. C. D. Kacalieff, Chairman of the Program Committee, reported that the tentative program would run all day Wednesday and Thursday, and Friday morning, with three sessions being held at all times. This will be a total of 15 sessions, and it is hoped to have no more than four speakers per session. Heavy consideration is being given to expanded question and answer periods at the close of each session. Tentative session topics are: New materials, instrumentation, properties of plastics, atomic and radiation considerations, end uses, film, extrusion, injection, foams, reinforced, compression and laminating, machinery and molds, vacuum forming, finishing, education, research, polyethylene.

A complete set of preprints will be given free with each registration at the Conference. Registration fees, as before, will be $10.00 for members, $15.00 for non-members, and $5.00 for ladies.

Hotel reservations forms, programs and registration materials will be mailed to the SPE membership early in November.

The entire program will be held at the Sheraton-Jefferson Hotel. Rooms for registrants are being held both at the Sheraton-Jefferson and at other nearby hotels. Entertainment suites will be available in several hotels on the basis of first come first served.

An important new feature will be a desk in the lobby of the Sheraton-Jefferson to be attended by various National Councilmen and officers to which registrants are invited to come for information or to make such suggestions or criticisms as they might like. The Executive Secretary, Jimmy Davidson, will be available at this desk a large part of the time.

St. Louis January 16-17-18, 1957

Industrial Literature

Catalog Available

A new 32 page condensed valve catalog, No. 201, is available from the Automatic Switch Company of 391 Lakeside Ave., Orange, New Jersey, manufacturers and designers of ASCO Solenoid Valves and Electromagnetic Control.

The latest designs in ASCO's extensive line of 2, 3 and 4 Way Solenoid Valves are included. It contains engineering information, flow charts, operation and construction details, illustrations, prices, etc. At a glance, from a unique selection chart, the reader can choose a solenoid valve to suit his requirements.

Snap-Action Thermostats

A condensed catalog listing physical, electrical and performance specifications for many types of snap-action, locally-adjustable thermostats is offered by Fenwal Incorporated, manufacturer of precision temperature controls. Copies of this catalog (please specify MC-120B) are available on request to Fenwal Incorporated, Ashland, Mass.

Manual Offered

Copies of "Recommended Practice for the Welding of Steel Castings," published by the Steel Founders Society of America, are available free from the Tempil Corporation, 132 West 22nd St., New York 11, N.Y.

File Folder Available

A handy file folder of U.S.I. Polyethylene Processing Tips has been prepared by the U. S. Industrial Chemicals Division of National Distillers Products Corporation, 99 Park Avenue, New York 16, N.Y., and is available upon request.

The folder was designed for reference files to answer the questions:

1. What operating conditions give best results with the various types of polyethylene resins on the market?
2. What types of polyethylene resins are available from U.S.I. and what properties do they have?
3. What services does U.S.I. offer polyethylene processor?

Revised Manual

A 48-page revised technical data manual on Coating Resins has been published by the Plastics & Resins Division of American Cyanamid Company.

The manual contains sections on Rezyl Resins, Cycopol Resins, Beetle Resins, Cymel Resins, and Phthalic Anhydride. Copies may be obtained by writing to Plastics & Resins Division, American Cyanamid Company, 30 Rockefeller Plaza, New York 20, New York.

Scott Testers

Brochures describing the new model CE Scott Tester and the model STI Mooney Shearing Disc Viscometer are available from Scott Testers, Inc., 47 Blackstone Street, Providence, R.I.

Thermistor Elements

Fenwal Electronics, now in full-scale production of precision thermistors, offers a well-illustrated catalog of its complete line of thermistor elements.

The 12-page, two-color catalog gives dimensional drawings, physical descriptions, and complete electrical specifications for various forms of precision thermistors, including beads, rods, discs, washers, and built-up assemblies. Copies of the catalog (EMC-1) are available on request from Fenwal Electronics, Incorporated, Mellon St., Framingham, Mass.

New Pipe

A brochure announcing the latest addition to the Danco line of nylon products — "Tempertube" nylon pipe —is available from the Danielson Manufacturing Company, Danielson, Conn.

Illustrated Bulletin

The advanced design features of the new Stokes Model 701 2-ounce automatic injection molding machine—are clearly portrayed in a new 8-page brochure, Bulletin 565, just issued by the Plastics Molding Equipment Division of F. J. Stokes Corporation, Philadelphia, Pa.

Copies of Bulletin 565 are available free on request from F. J. Stokes Corporation, 5500 Tabor Road, Philadelphia 20, Pa.

Men In The News

Vice-President Named

Appointment of John C. Hamilton as vice-president, manufacturing, of Canadian Resins and Chemicals Limited is announced by R. J. Southwell, president, effective immediately.

Mr. Hamilton, works manager of the company's plants at Shawinigan Falls and Ste. Therese, Que., since last October, was previously general superintendent of plants. He joined Canadian Resins in 1943 and, prior to becoming general superintendent in 1953, was successively plant production supervisor and production superintendent.

Simons Appointed

William G. Simons, formerly in charge of customer service work in the Reinforced Plastics section of the company's Stamford Laboratories, has been appointed Technical Service Representative for adhesive, laminating and reinforced plastics resins in the Plastics and Resins Division, American Cyanamid Company, with headquarters in New York City.

Three Appointments

Improved Machinery, Inc., Nashua, New Hampshire, announces the following appointments: Winthrop A. Fleming and Robert S. Ward as Sales Engineers; and Sidney O. Arnold as Service Representative.

Mr. Fleming, who resides in Leominster, Massachusetts, was formerly with Standard Tool Company in Leominster.

Mr. Ward also resides in Leominster, Massachusetts, where he has been employed with Foster Brant Company since 1937.

Mr. Fleming will cover the New York State area, and Mr. Ward will represent Impco. in New England.

Mr. Arnold resides in Burbank, California, and will serve in the capacity of service representative in the West Coast area.

MOLD DESIGN SERVICE

W. A. Hart of St. Charles, Illinois, announces a complete mold design service for Midwest molders and mold building jobbing shops. Associated in the industry for over twenty years, with a complete knowledge of all types of molds, the problems of production and finishing, the need for standardization, and good mold construction, he offers a service based on experience. Interested companies can request a Mold Information Chart which they can fill out for complete information and quotation without obligation. Mailing address is Route 1, Box 278, St. Charles, Illinois. Phone St. Charles 6473.

NEWS of the industry

Polymerization Plant

A new polymerization plant with an initial annual production of 10 million pounds of polyvinyl acetate was to be opened at Demopolis, Ala., Aug. 1 by the Polyco-Monomer Department of the Borden Company's Chemical Division.

In making the announcement, Augustine R. Marusi, president of the Division, said it is the first such operation in the Deep South. It was decided to establish the plant, he added, because of the growth of the paper, textile, adhesives and paint industries in the area. All have polyvinyl acetate applications.

New Corporation

The Brook Molding Corporation, a newly formed corporation is now fully operative and ready to serve customers in their industrial custom molded needs.

The all new, modern one story plant, located on Route #1 in Norwood, Mass., was designed for ease of material handling and low cost, high quality production; and contains the latest, most up-to-date injection, compression and transfer equipment.

License Negotiated

Spencer Chemical Company announced today that it had negotiated a license with Standard Oil Company (Indiana) for their low pressure process of making polyethylene and polypropylene. This process is protected by more than 20 issued patents, as well as a number of pending applications, covering polyethylene, polypropylene, and copolymers of ethylene and propylene. Standard Oil is the first company to be granted U.S. Patents on a commercially feasible process for making high density polyethylene.

Expansion Started

Expansion of production facilities for methyl methacrylate monomer, the raw material for "Lucite" acrylic resin products, is under way at Du Pont's Belle Works, near Charleston, W. Va., it was announced today.

The project, which will double Du Pont's capacity for manufacturing methyl methacrylates, is expected to be completed in about two years.

According to Du Pont, forecasts of wider markets for all acrylic products in the next several years accounted for the decision to expand methacrylate capacity.

Plant to be Built

An $11 million plant for the manufacture of methyl methacrylate will be built by Hercules Powder Company and Imperial Chemical Industries Ltd., of England. The new plant with an annual capacity of 35 million pounds will be built on a 20-acre site at Louisiana, Missouri, adjoining Missouri Ammonia Works, owned and operated by Hercules Powder Company.

A new company will be formed to build and operate the methyl methacrylate plant, with Hercules and Imperial Chemical Industries Ltd. each owning 50% of the new corporation.

Standard Established

A commercial Standard for Rigid Polyvinyl Chloride Plastic Sheets has been issued by the Commodity Standards Division of the U. S. Department of Commerce. The establishment of this Standard and Amendment No. 1 to it was proposed by the Thermoplastic Structures Division of The Society of the Plastics Industry, Inc.

This Commercial Standard CS201-55 covers physical and chemical properties, methods of test for high impact and normal impact chemical-resistant Rigid Polyvinyl Chloride Plastic Sheets. These sheets are suitable for fabricating equipment and structures by hot-forming and plastic welding techniques.

A recommended method of declaring compliance with the standard has been incorporated in it.

Amendment No. 1 covers the two hallmarks which have been adopted for the use of manufacturers in identifying products conforming to Commercial Standard CS201-55. The hallmark for Type I covers the normal impact chemically resistant rigid PVC sheets, while Type II covers the high impact, chemically resistant rigid PVC sheets.

The Thermoplastics Structures Division of SPI is actively preparing Performance Standards on materials such as polyethylene, and the polyfluorocarbons used in the construction of industrial structures. The Division is also developing a manual for PVC fabricators which will contain fabrication techniques and design criteria.

Companies Merge

Arrangements for merging Hydraulic Press Manufacturing Co., Mount Gilead, Ohio, into the Koehring Company of Milwaukee were completed when a stockholders' meeting of the Koehring Company ratified the agreement. The merger became effective Saturday, June 30.

Julien R. Steelman, president of Koehring, said that an excess of 12% of the outstanding shares required to approve and adopt the merger plan was voted in favor of the merger. At a similar meeting on June 14, stockholders of H-P-M approved the plan overwhelmingly.

G. B. Robinson, chairman of H-P-M, has been named to the Koehring board of directors. No changes in the management or policies of H-P-M are contemplated, Steelman said. The company will be operated as a division of Koehring.

New Fabric Introduced

A new fabric for tarpaulins and similar protective coverings combines translucency with high strength, low weight, weather resistance and other advantages.

The new material, being introduced by Herculite Protective Fabrics Inc., Belleville, N. J., is made of loose mesh weave Fortisan-36 (Celanese high strength rayon) laminated between two outer vinyl coatings. The vinyl is Bakelite Krene.

In addition to offering considerably greater strength and dimensional stability than natural fibers, Fortisan-36 is resistant to the sunlight degradation that attacks certain other fibers; thus, it makes practical a strong translucent tarpaulin-type fabric, as contrasted with the conventional opaque materials.

In addition to industrial potentialities, the Herculite company feels the new fabric has interesting characteristics for a number of consumer applications, notably in translucent awnings that would provide soft shade for intense sunlight without blotting out all light. For such a use as this, the vinyl can be provided in a variety of colors.

Fabric source: Herculite Protective Fabrics, Inc., 140 Little Street, Belleville, N. J.

Heat Resistant Material

The development of a new heat resistant medium impact phenolic molding material has been announced by the Durite Department of the Borden Company's Chemical Division. Designated as "HR-322", it is expected to meet the growing need for these properties in a general purpose material.

THE INJECTION molderscope

By A. R. Morse

President, Injection Molder's Supply Co.

Personal Animosity

In a recent report to SPI Molder Members there is an interesting commentary by Harry Haaxma, Chairman of a group called "Relations with Raw Material Suppliers, Machinery Manufacturers and Mold Makers". His group sent out a questionnaire on that subject. It elicited so many expressions of "personal animosity" that it had to be scrapped and another one prepared! This leads me to two commentaries of my own, on tender subjects. The process of hammering together molecules to produce a synthetic product is both difficult and subject to many variables. On the sales level, the injection molder may sometimes be led to expect both perfection and uniformity in his plastic molding powders—but if one looks behind the gleaming storefronts you see an entirely different picture. You see skilled technicians attempting to make nature behave in an unnatural way, something that is really quite difficult to do and to control. For the molder to inject into his mutual problems with the material supplier any such degree of "personal animosity", is for him to overlook the difficulties of synthesizing his vital raw material (plastics) from the basic elements. I cannot help but believe that if the material companies would let the molder see behind their elaborate sales department facades, and if more molders would visit the chemical plants, it would do a great deal to eliminate "personal animosity" and spread understanding of what a terrific job all the powder people are really doing. The truth is that the average molder knows little and cares less about material manufacturing problems, and all too often fails to grasp just what modern miracles are involved in the synthesis of his raw materials.

My second comment in this touchy area is in the relationship of molder and machinery supplier. The molder sees a vast difference in engineering estimates incorporated into all the different makes of machines. In clamp ratings, in cylinder ratings, and in press performance, the sales department obviously takes a strong hand in shaping performance estimates. But in other less glamorous details, there exist a host of glaring inconsistencies. When presses are down for any reason it is understandable that "personal animosity" might be generated, and possibly sometimes with reason. One engineer figures tubing strength one way, and another, another. For example, no machinery supplier ever put out a piece of equipment in conscious bad faith. We ran out of grinder blades recently and were liberally castigated both on a personal and company level by a molder, but we didn't **like** to be out of blades—it was just one of those "runs" that any equipment supplier sometimes gets on a given part. Stock plenty and you get no calls. But let the stock run out and the demand is terrific! Let the injection molder visit the machinery supplier, see the problems of stocking repair parts, both physically and financially, and he will understand a little better that he should not interpret the problems of the equipment supplier in terms of "personal animosity".

One reason for so much "feeling" among molders about their various suppliers is that the molder himself is very close to his own customers as a rule, and much of his own selling is on the impulse or emotional level. Because production runs are so short and inventories so low today, the molder is often skirting the edge of a raw risk, and delays really hurt him.

Other molder groups in SPI studying such topics as "Insurance on Molds, Discounts and Prepaid Freight" and "Set up, Color Change, and Mold Withdrawal Charges," and "Methods of Estimating" reveal that in many instances the molder is not making an adequate profit because he has not figured on all contingencies. As one reads the SPI report on "Molder Members Activities", one can not help but admire Messrs. Rau's and Cowan's energetic leadership. We only hope that they will work to eliminate this unfortunate element of "personal animosity" that we all know does exist here and there in the molding industry.

To a certain extent, this "personal" feeling probably derives from the fact that many injection molders are relatively small, and yet they are dealing with some of the world's largest businesses. When they find they are up against immovable forces, there is only one way to express their utter frustration over the situation, and that is on a personal level. But if the material and we machinery people both are a little readier to admit our own human failings, I believe the molder will not judge us so severely, and a more friendly and mature business relationship can be reflected in such a questionnaire as Mr. Haaxma has just circulated.

The Injection Molderscope solicits articles on any phase of injection molding from anyone who has ideas he wants aired. We want stimulating articles and comments from anyone that can be adapted for publication. So let us hear from you — on machinery, on powders, on molds — it is your chance to be heard.

Barrett Adds New Representative To Plaskon Resins Sales Staff

The appointment of John H. Lambert as sales representative for Industrial Resins Sales has just been announced by the Plastics and Resins Sales, Barrett Division, Allied Chemical & Dye Corporation. Mr. Lambert was formerly sales representative for G. A. Olson, agent for Reichhold Chemicals, Inc., in the Philadelphia Area.

Lambert's appointment fills the position left vacant when Mr. W. H. Hough was recently appointed Industrial Resins District Sales Manager of Barrett's newly formed New York District Office.

Canadian Resins Appoints Malone

Appointment of Maurice F. Malone to the newly-created position of sales development representative, industrial products division, is announced by Canadian Resins and Chemicals Limited.

Mr. Malone, a technical representative in this division since joining the company in 1952, was transferred to Montreal last November from the Toronto district office.

Succeeding him is H. Lorne Burrows, who is now responsible for compound, calendering resin and plasticizer sales in the Montreal area.

AROUND THE WORLD

AUSTRALIA

AUSTRALIAN PLASTICS

Vol. 12, No. 130, May, 1956

Abstracter: Albert Lightbody

HIGH FREQUENCY WELDING OF PLASTICS SHEET—E. C. Stanley

Applications of dielectric welding of sheet material are given such as motor-car trim, seat covers, roof linings, using both supported and unsupported film. The practical limitations of both the welding equipment and the work to be done, giving die pressures, temperatures, dimensions, are listed for particular applications. Two frequency bands are used, 18-20 mc's and 35-38 mc's. The higher frequency is favored due to low arcing tendencies.

GERMANY

KUNSTSTOFFE

June, 1956

Abstracter: Anne Schwend

PROPERTIES AND FIELDS OF APPLICATION OF PLASTIC PACKAGING FILMS—Waldemar Tiebel

A rough survey on film production methods is followed by resume of film properties and comparison thereof. Several charts clearly classify film groups as to commonly used thickness, weight and forms of supply, resistance to acids, lyes, oils and fats etc., gas permeability plus an overall chart showing particulars on properties, kind of application, processing, printing and others.

PLASTIC-COATED PAPERS—Walter Schoch

Plastic lamination processes, machinery and coating varnishes as developed during the last few years as well as properties thus bestowed on papers are discussed under particular consideration of semi and fully-automatic packaging.

LAMINATED ALUMINUM-PLASTIC FILMS—K. Broockmann and R. Schnell

Out of the many possibilities of laminating plastics with aluminum foils and paper, those laminates are specially considered the properties of which have contributed considerably to open a large market as packaging materials, particularly for the foodstuff industry. Though none of the materials used would, alone, meet the demands as to water vapor and air tightness, protection against insects or insecticides, light transmission and, hence, protection against spoiling of edible goods, a combination of them will do so. The excellent heat reflection properties of aluminum foils, especially of mat surfaces, will not permit any stowage of heat inside the packages. The most widely applied production and heat sealing techniques are aired.

RIGID PLASTIC CONTAINERS AND TRANSPARENT PACKAGING—E. Escales

A discussion of plastic materials, processing techniques and properties as shown by rigid and transparent containers.

PLASTIC BAGS—J. Hausen

A survey of bagging materials, i.e. plastic films and paper-plastic laminates, is followed by a brief discussion of delivery programs of various German firms. A pre-formed PVC bag shrink on ready-packed cartons is mentioned as a novelty for Germany, although "Flex-Vac" packaging is well-known in the States. Lamination techniques for paper/plastics combinations, results of permeability tests, bag shapes, bagging machine types, seals and sealing machines are dealt with.

COLD STRETCHING OF LOW PRESSURE POLYETHYLENE—K. Richard and E. Gaube

The mechanical behaviour of low pressure polyethylene under temporary loads is discussed in detail. The stress-strain diagram shows the same characteristics as that of all other stretchable plastics. With an increase in temperature the extent of uniform stretching prior to formation of necks amounts to more than 100%. Material cooled down in such elongated status will retain shape until original shape is restored partially or completely by reheating. Strength increase shown by such frozen state of orientation is around 100% against original yield point.

Densitometric tests proved that practically no change in density takes place upon stretching, rather only a dissolution of crystallites prior to formation of necks, flowing of molecules through the neck and a re-crystallization, newly formed crystals being oriented in stretching direction. Genuine stretching with formation of necks is, hence, only feasible below melt point of crystallites. Strength values may be more than tripled, depending on stretching temperature. No strengthening, however, only orientation will occur if material is slowly and slightly stretched above melting point of crystallites. Strong, rapid stretching at such temperatures again increases strength values. Modulus of elasticity of low pressure polyethylene of 8000 to 10000 kg/sq. cm. rises to 26000 kg/sq.cm. when stretched at ambient temperatures.

Stretching tests at right or varying angle to original stretching direction reveal that no gain in strength can be thus achieved.

DETERMINATION OF GAS PERMEABILITY OF PLASTIC FILMS—Dr. W. Schruefer

Based on the principle of measuring changes in pressure and volume explained in part I (see April abstracts), a simple new device was developed for measuring the gas permeability within .005 to 50 cu.cm./sq.dm. by day by atm. of plastic films and papers coated one one side. Prerequisite is use of dry gases, absence of rubber from tight-sealing measuring chamber. Easy handling makes apparatus suited for continuous operation.

BONDING OF PACKING MATERIALS—Dr. W. Bartusch

In overlapping bonded joints the edges of the bonded seams are exposed to the greatest stresses, structural changes will therefore highly influence the behavior of the band. An empirical equation facilitates interpretation of the bursting strength of

(Please turn to Page 58)

SPEAKING OF EXTRUSION

Edited by **R. D. Sackett**
Technical Service Associate
Monsanto Chemical Company
Springfield, Massachusetts

Extrude For Your Market

Fred J. Myers
Texas Plastics, Inc.
Elsa, Texas

The market characteristics and the manner in which these factors influence the demand for polyethylene film and its products must be considered along with the technical aspects in determining the type and size extruder that will enable you to compete in a field that is steadily becoming more and more competitive and specialized.

The design of your extrusion equipment will determine the quality and physical characteristics of the polyethylene film that you produce, but the decision must be tempered with sound business judgement, understanding of the market and the subsequent production problems of your customers.

For the sake of discussion, the major markets for polyethylene film will be divided into: (1) small volume, non-critical applications (2) small volume, high quality applications (3) large volume, high quality applications. The feasability of extruding flat film, small diameter tubing, or large diameter tubing for each of these markets will be evaluated based on actual production operations and the problems introduced by the market demands.

Small Tubing

Small tubular extruders, 2½ inches and under in diameter, are by far the most practical for small volume specialty and non-critical operations. They are easily adapted to continuous operation combining extrusion, treating, printing and bag making with a minimum of expense. Despite relatively low production rates (12 to 18 pounds per hour on tubing for one and two pound produce bags, and up to sixty pounds per hour on large, heavy gauge film) there is no way of competing with this type operation for small volume orders. The same die will afford a wide range of flexibility while still maintaining good toughness and transparency by varying the "blow-up ratio" from 2 to 3:1 and using a fairly high compound temperature; decreasing the compound temperature and reducing the "blow-up ratio" to approximately 1.5:1 results in a slightly weaker film with far superior slip and blocking characteristics. Extrusion of this type is generally of the "custom variety" due to the infinite combinations of thickness, face width and gusset depth.

"Single Face Printing" predominates because of problems in treating both sides of the film, difficulties in reversing stations of a stack type press for "double face printing," and the need for slip sheeting to prevent "offset." Tubular bag making equipment is simpler and less expensive than machines for either the "back-seam" of "side weld."

Though the extruder speed is generally the limiting factor in a continuous line, because of the lower initial investment, flexibility, small amount of scrap and minimum down-time for set-up, the small tubular extruder is best suited for the small volume, or non-critical orders which exist in large numbers in the United States and are characteristic of foreign countries where polyethylene is beginning to achieve recognition as a packaging material.

Large Tubing

Major domestic extruders favor the production of polyethylene film as large diameter tubing. Tubing up to twelve feet in diameter, and speeds exceeding two hundred feet per minute are readily achieved due to the development of specially designed dies, cooling mechanisms and rewinds. Despite the high initial investment for machinery, extrusion lines of this type, with production rates from four hundred to six hundred pounds per hour, are ideally suited and economical for long runs. Though the cost of a large tubular extrusion line is approximately ten times that for a small extrusion line, the production rate is about 2.5 to 4.0 times as high per dollar invested, and from 10 to 25 times as high per man hour of labor. The bulk of this large tubing is slit to flat film though an increasing portion is being used as waterproofing for housing foundations, tarpaulins, and temporary outdoor structures as greenhouses and chicken coops.

The primary production limitation of tubular extrusion is the cooling rate of the tubing for blocking occurs if this is inadequate. The temperature of the air inside the "bubble" should be controlled or the volume maintained constant to prevent the size and thickness of the tubing from varying. The velocity and temperature of the air emerging from the cooling rings must be equalized to insure uniform cooling; as more slowly cooled areas stretch more under bubble pressure, giving thinner gauge. Processes to more effectively cool by means of humidified air and rotating (90° reciprocating) cooling rings, as well as devices to control the temperature and volume of the air inside the bubble have been patented by two of the major firms specializing in extrusion.

Slit Tubular Film

The slit tubular film is largely consumed in the manufacture of plain or printed bags of the back-seam, side weld, or pouch varieties. Though the price of this film is below that of small tubing, the higher scrap loss and longer set-up time makes it impractical to compete with tubular bags on small volume and non-critical orders. This "flat film" is ideally suited for large volume, printed, critical applications where the film is printed on either "central impression" or "stack type" printing presses, at speeds of three to five hundred feet per minute. Major produce shippers using carrot or radish bags require three and four color printing completely around the bag, in volumes frequently exceeding one million bags weekly. Nothing but flat film could satisfy the requirements of such customers at a competitive price. The bags are generally run three or four across on a wide film which is subsequently slit for bag making. Printing rates of 70,000 to 120,000 impressions per hour are requisite to compete effectively. Small diameter tubing would be impractical for a converter in this market; and the vertical operation with a small tubular extruder as its foundation would be unable to compete.

Flat Film Extrusion

A large part of the domestic flat film is produced on medium sized ex-

truders from 3¼ or 3½ inches to 4½ inches in diameter. In this size range, the production rate per dollar investment, and per man hour of labor, compares favorably with that on the large tubular extruders. At representative commercial operating speeds of 150 to 200 FPM, and film thickness from 1¼ to 2½ mils, the productive capacity of a 3½ inch extruder may efficiently be utilized with dies from 30 to 40 inches wide; the capacity of a 4½ inch extruder would be equally efficiently utilized with dies from 54 to 70 inches wide. Best quality and most uniform gauge are obtained in the range of 40 to 70% of extruder capacity. More uniform gauge is possible with flat film than in tubular film because of the inherent design of the dies and manner of cooling. With 1¼ through 2½ mil films, a plus or minus 0.1 mil tolerance is readily maintained in flat film though the tolerance for tubular film approximates plus or minus 0.3 mils.

Tubular film has a higher degree of biaxial orientation than flat film since the former extrusion method permits a "two way stretch" in the molten state, whereas the latter is limited to stretching in the machine direction. Recent improvements in flat film die designs and in the physical characteristics of the resin have narrowed the gap between the two types of films. The more uniform gauge of the flat film has enabled it to compete with tubular film for the same applications and with equally satisfactory results.

Production of film wider than approximately forty inches requires inventories and slitting "to width" since the bulk of flexographic printing presses are either of the 28 to 30 inch width or the 40 inch width. Just as the problems with gauge control and wrinkling multiply very rapidly in tubing exceeding 12 inches in diameter, the problems in flat film grow more complicated as width exceeds approximately 40 inches. Excellent large scale operations have been achieved with 6 inch and 8 inch extruders and dies up to 120 inches wide. The width of the film produced from any die may be varied by increasing or decreasing the distance of the quench bath (or casting rolls) from the die; as the distance is increased, however, it becomes more difficult to maintain uniform gauge.

Dies must be handled with care since warping may occur from stresses introduced by too rapid cooling during shutdown or from "green" materials used in the initial construction. With proper handling, the same die may be used for several months without cleaning or major adjustment. Die rods for adjusting the effective width of the die are impractical since the stagnant polyethylene behind these rods decomposes rapidly making

(Please turn to Page 63)

8 GALLONS of plastic pail

colored perfectly every time

Flexible, dent-proof, seamless utility pail of polyethylene, made by Republic Molding Corporation, Chicago, Ill., and colored with Gering DRYCOL.

with GERING Drycol

When Republic wanted a coloring agent for this big polyethylene pail, they knew they would get perfect results with Drycol, Gering's one-step unit-packaged coloring agent.

The pigments in Drycol are the same time-tested pigments used in compounded thermoplastics you buy already colored. They are light-stable, heat-resistant dust-free, and carefully color-matched by Gering.

Drycol is packaged in units to color one hundred pounds of plastic. You have no weighing to do—and no chance of error.

Drycol helps you produce special orders in a hurry . . . cuts your inventory costs on colored plastics.

Immediate shipment of all standard and special colors.

Blend-Eze, Gering's specially developed wetting agent, can be used with Drycol to give superior color dispersion and eliminate dusting.

Drycol is also available in special tinsel, metallic, and pearl effects. It will pay you to check with our technical service department.

DRYCOL

the one-step plastic coloring

GERING PRODUCTS, INC., KENILWORTH, N. J.

Pioneers in modern plastics for over 30 years!

ASTE Research Fund Announces Plastic Tooling Research Project

An intensive research program on Properties of Plastics Used for Tooling Applications has been initiated by the American Society of Tool Engineers Research Fund. A $10,000 contract has just been awarded to the Purdue Research Foundation. Work will be carried on under the direction of O. D. Lascoe, Professor of Manufacturing Processes in the Department of General Engineering.

In conjunction with the ASTE Research Fund, cosponsors of the project include: The Bakelite Co., Division of Union Carbide and Carbon Corp.; Shell Chemical Corp.; Ciba Co., Inc. and Marblette Corp.

Research in methods of measuring the characteristics of plastics as applied to plastic tooling is incomplete. No successful attempts have been made to determine the individual effects of the major variables influencing plastics in the field of tooling. The Purdue Research Foundation will conduct a study of four variables in two six-month phases.

The first phase involves a complete survey of existing literature and visits to plants experienced in plastic tooling applications. This information will be compiled into a report summarizing tested engineering data, thereby establishing a basis for conducting future investigations.

The second phase will be devoted to the establishment of standard test methods for measuring and predicting reactions of the variables involved, in order of importance: shrinkage characteristics, abrasion resistance, heat resistance, and physical properties essential in plastics for tooling in stamping and forming operations.

Additional studies will be made in each case to determine the specific results which may be expected when any one of the variables is altered. The final findings will then be compiled into a basic manual for tool engineers involved in plastic tooling.

The ASTE Research Fund will welcome research ideas and proposals. For further information write to Leslie S. Fletcher, Research Director, ASTE Research Fund, 10700 Puritan Ave., Detroit 38, Michigan.

New Cold Curing Flexible Mold Compound Gives High Fidelity With Negligible Shrinkage

A new polymer-base mold compound in liquid form has been developed for use in forming flexible molds over patterns made of plaster, wood, metal, clay, or wax. This material, known as Poly-Flex 100, is produced by Smooth-On Manufacturing Co. of Jersey City, developers and Manufacturers of Metalset and Sonite epoxy resin compounds, and (since 1895) Smooth-On iron cements.

Poly-Flex and its curative come in a liquid state. The material is white. The two components are readily mixed and the resulting compound has low viscosity. Pouring is easy. It cures in about four hours at room temperature.

Cured Poly-Flex 100 has good aging characteristics, is resistant to solvents, oils, greases and dilute aqueous solutions, and will withstand intermittent service temperatures about 200°F.

Poly-Flex 100 cures in intimate contact with all pattern surfaces with negligible shrinkage. It has great fidelity. Because of its low viscosity the problem of entrapped air is markedly reduced. Parting from patterns is easy, the model requiring no special preparation other than greasing.

Poly-Flex 100 is recommended for the making of pattern duplicates for vacuum molding and for the ceramic industry. It is available in quart, gallon, and 5-gallon sizes from Smooth-On Manufacturing Co., 572 Communipaw Avenue, Jersey City 4, N.J. Technical bulletins are available.

Book Review . . .

An Encyclopedia of the Chemical Process Industries, by Jeffrey R. Stewart, F.A.I.C., assisted by Frances E. Spicer. (Chemical Publishing Co. Inc., New York, 1956, 820 pages, $12.00)

This is a concise alphabetical dictionary of technical terms used in the chemical industry. As such, it covers a wide territory from manufacturing processes to analytical chemistry, physical chemistry, biochemistry and even microbiology.

For products listed, it gives the essential chemical characteristics, uses, and often manufacturing processes and names of the manufacturers.

In an addendum of 50 pages, the authors give the description of chemicals generally known by their tradenames, and this part of the book will be very valuable to prospective users of these chemical specialties.

There are omissions, but they are to be expected in a book embracing such a large scope. As it is, it will be most useful to the legions of chemists all over the country.

Louis C. Barail

MANCO

'TRU-CAST' Beryllium Copper Mold Components Have Everything You Need

- Long Life
- Fidelity of Detail
- High Impact Strength
- Close Dimensional Tolerances
- Trouble-Free Performance

These "built-in" advantages, plus quality guaranteed by over 40 years of Manco casting experience, go into every 'Tru-Cast' cavity and core —adding up to better, faster production at substantial cost savings. **Write, wire, or phone today** to bring your production problems to Manco — a copy of the 48-page 'TRU-CAST' HANDBOOK will be sent to qualified firms upon request.

MANCO PRODUCTS, Inc.
2401 Schaefer Road, Melvindale, Mich.
Telephone: Detroit—WArwick 8-7411

Hudson Red Light

NEW ADDITION TO OUR LINE OF DEPENDABLE RED PIGMENTS

HUDSON RED LIGHT
IN VINYL PLASTICS AND RUBBER

Excellent ease of dispersion
Excellent heat resistance
Excellent resistance to migration and crocking
Non-bleeding in water, dioctylphthalate, tricresyl phosphate
Fair to good fastness to light

HUDSON RED LIGHT
IN LITHOGRAPHIC, TYPOGRAPHIC, INTAGLIO INKS
(TIN PRINTING AND FOOD WRAPPERS)

Excellent softness of grinding
Good baking resistance
Non-bleeding in brine, hydrocarbon solvents, alcohol
Resistant to bleeding in paraffin, fats, greases
Fair resistance to soap
Good fastness to light in fullshade and tint

HUDSON RED LIGHT
IN PAINTS

Excellent ease of dispersion
Non-bleeding in linseed oil and mineral spirits
Excellent resistance to acid
Fair resistance to alkali
Good fastness to light

We invite you to investigate the advantages of Hudson Red Light over competitive products—such as softness in grinding and fastness to light. In addition to its high tinctorial value, Hudson Red Light passes 100% through a 325 mesh sieve.

Make a practical plant trial of the dependability of Hudson Red Light for your own uses. Kindly call upon the services of our Technical Department—or our nearest sales office.

From Research to Reality

gdc gaf

GENERAL DYESTUFF COMPANY
A SALES DIVISION OF
GENERAL ANILINE & FILM CORPORATION
435 HUDSON STREET • NEW YORK 14 • NEW YORK

BOSTON • CHARLOTTE • CHATTANOOGA • CHICAGO • LOS ANGELES • NEW YORK • PHILADELPHIA • PORTLAND, ORE. • PROVIDENCE • SAN FRANCISCO • IN CANADA: CHEMICAL DEVELOPMENTS OF CANADA, LTD., MONTREAL

Frankly SPEaking

Dear Friends:

Have you ever read a magazine or newspaper article just because the title sounded interesting? Have you ever found that the title promised more than the article could deliver? If so, you are quite average. It seems that so many of these articles turn out to have very little to do with the intriguing titles. All this is by way of preface to saying: "The HEADLINE writers will get you if you don't watch out!"

HEADLINE: "AT LAST, LIZ TAYLOR TELLS THE TRUTH ABOUT HER MARRIAGE!" I had observed several previous reports about this particular marriage. Am I now to believe that all previous reports were lies? Why should I believe that this latest "truth" is any more (or less) truthful than all the others? The headline writer has created suspicion in my mind simply because he said the report is the truth. Wasn't it Shakespeare who had one of his characters in Hamlet say, "The lady doth protest too much, methinks." I could cite many other headlines which create suspicions, but let me confine myself to just a few. "Lung Cancer and Smoking; What we really know" is a good example. "Berle tells what happened to his career", "The Great Fluoridation SCARE", "The Truth About Cancer" are but a few more that you might find in any paper or magazine. The Holy Scriptures say "But let your communication be Yea, yea; Nay, nay: for whatsoever is more than these cometh of evil." (Matt: 5:38)

HEADLINE: "BILL BANS ICEBOXES" This small headline appeared in our paper a few days after Congress adjourned. The 10 lines of copy that followed failed to support the headline. The copy stated that the purpose of the bill, which was now up for Presidential action, was to save the lives of many children who were trapped in old iceboxes every year. I am still confused since I failed to see the logic in the Congressional action. In the first place, aren't old electric refrigerators just as dangerous as iceboxes? Secondly, by what right did Congress put icebox manufacturers out of business? Third, Just how would banning iceboxes save all these lives? Fourth and most important, If the precept of saving lives by banning the immediate cause of decth is a good precept, why not start with banning the automobile which takes more lives in one day than old iceboxes take in one year? I think this article should have had either a different headline or further copy to support the headline as written.

HEADLINE: "OBSERVERS THINK BUTLER WILL KEEP HIS JOB IF ADLAI WINS." In this case, the observers are identified only as "friends" of Mr. Butler. This news story as a whole can be classified as opinion, surmise and guesswork. Of what value is such guesswork when it is predicted on the possible occurance of certain events in the future? There will undoubtedly be many such headlines and stories in this election year. In fact, the biggest offenders will be the many newscasters and election news analysts who will start their reports with something like this: "Well, folks, it seems certain that the next event will result favorably for — —, but on the other hand, it may not because —". For my money, these fellows are wasting time.

Perhaps you may have felt that reading this article was a waste of your time. You did take time to read it, didn't you!!!!

Yours for better Living with Plastics

Wayne I. Pribble

British Plastics Federation's World Wide Service

Steps are being taken to make better known overseas the unique service offered by the British Plastics Federation in publishing each month abstracts from technical articles in journals throughout the world dealing wholly or partly with plastics developments. The service includes the publishing of patents from the countries which have an important plastics industry.

The abstracts service costs 10 pounds, 10 shillings a year (post free). Abstracts are available in bound or unbound versions, the latter being printed on one side only. Photostat or microfilm copies of most articles can also be obtained from the Federation, whose offices are 47-48, Piccadilly, London, W.1., England.

So far, abstracts go to 26 overseas countries, Australia, U.S.A. and Russia being the largest three buyers. Others taking the abstracts in quantity include Germany, Holland, France, Czechoslovakia, China, South Africa and the Scandinavian countries.

It is usually possible to supply photostats or microfilms of the original articles at moderate cost.

Reynolds Appointed

The Plastics Division, Celanese Corporation of America, has announced the appointment of Charles M. Reynolds as sales director for the Division's newly-established Sheet Department. Mr. Reynolds, who lives at 710 Tuxford Turn, Westfield, N.J., was formerly assistant director of sales for film.

Rudolph L. Jacob

Rudolph Louis Jacob, 71, owner of the Cranston Molding Co. and a pioneer in the plastics industry, died yesterday at Miriam Hospital after a short illness. He lived at 3922 Post Rd., Warwick.

The husband of Matilda F. (Knoeller) Jacob, he was born in Newark, N. J., Dec. 19, 1884, son of the late Fred and Mary (Boppel) Jacob. He came to Rhode Island in 1943.

A mechanical engineer, he had served as chief engineer for the Garfield Manufacturing Co., one of the earliest plastics molding firms in the country. He was experienced in molding bakelite powders and designed and built early hydraulic presses for the Burroughs Co. in Newark.

PLASTICS Around the World

(Cont'd from page 53)

joints as well as calculation of maximum feasible thickness of joints. The loss in strength observed when increasing the thickness of joints is assumed to be due to molecular orientation taking place in the border zones of bonded joints under influence of contractions during setting period.

ICI HIGH PRESSURE, HIGH DENSITY POLYETHYLENE

Preview of properties of "Alkathent HD", rigid, sterilizable polyethylene, to be introduced shortly on the British market.

PLASTIC STOPPERS FOR BOTTLES AND TUBES—W. Laeis

Typical examples of different kinds of stoppers, particularly considering advantages offered by polyethylene, are reviewed.

PLASTIC FOAMS AS PACKING MATERIALS—Dr. F. Stastny

Three types of foams: "Iporka" (urea formaldehyde), "Moltopren" (on the basis of polyester diisocyanate) and "Styropor" (polystyrene) as commonly used in Germany for packing purposes are discussed. Similar U.S. plastic foams are cited.

★

GREAT BRITAIN

RUBBER AND PLASTICS AGE

Vol. 37, No. 7, June, 1956

Abstracter: Watson C. Warriner

LARGE DIAMETER NYLON PIPE FOR EXPORT—Staff Written Article

Description and pictures of extruder, vacuum takeoff and techniques used in the continuous extrusion of nylon pipe 5.563 inch in diameter with a wall thickness of 0.258 in. The pipe is used in the oil fields as a lining for control wells to facilitate the measurement of the oil/water demarkation line in the region of the oil sands.

(Continued from Page 42)

vice in many applications. They range from 10^8 to 10^{10} ohm-centimeters at room temperature and drop about one order at 160°F.

Casting compounds based solely on polysulfide polymer have electrical properties of the same order of magnitude as the modified epoxy resin compounds. The more highly crosslinked the polysulfide polymer, the better its dielectric strength appears to be. Thus, for a formulation containing 30 parts of Albalith (a lithopone filler marketed by the New Jersey Zinc Sales Co.) and cured with 15 parts of C-5 paste (50% lead dioxide, 45% dibutyl phthalate, 5% stearic acid), 100 parts of LP-32, which has only one-half percent crosslinking, had a dielectric strength of 287 volts per mil of thickness while the same amount of LP-2 with two percent crosslinking withstood up to 341 volts per mil. The Thiokol based compounds, when cured with the lead dioxide paste have dielectric constants slightly higher than the modified epoxy resin compounds, dissipation factors a whole order lower, but with volume resistivities slightly poorer. In Table XI some electrical properties for some filled LP-32 compounds are shown at 80°F. These tests were run on sheets pressed out at 287°F for ten minutes followed by a 24 hour conditioning period at room temperature. Elimination of the sulfur from the formulations will give a less resilient compound but will improve the dissipation factors even further.

V. Chemical Protection

The polysulfide polymer-modified epoxy resin compounds, and to a lesser degree, the polysulfide polymer based compounds, have excellent adhesion to many materials. Where adhesion is poor, the low shrinkage of these compounds still maintains good mechanical adhesion. In either case foreign matter is sealed out of the potted unit. However, this does not mean that water, water vapor, solvents and chemicals and their vapors cannot enter the unit through the molecular network of the compound, or attack and corrode away the resin itself.

It is generally accepted that moisture vapor transmission is aided by the presence of polar groups. Since the polysulfide molecules are considerably less polar, addition of these amorphous materials to the epoxy resin dilutes the concentration of polar groups and thus reduces the amount of water vapor transmitted. This is shown graphically in Figure V for several DMP-30-cured commercial epoxy resins. All moisture vapor transmission tests were run according to ASTM procedure D814-46T.

On the other hand, water absorption characteristics are generally poorer when increased amounts of LP-3 are added to the formulation. Figure VI shows typical results obtained for LP-3/epoxy resin compounds. In this case Epon 828 was the epoxy resin used and DMP-30 was the curing agent, with the ratio of polysulfide polymer to epoxy resin as the parameter. Note that the blend containing 33 percent LP-3 (1:2 ratio) is slightly superior than the unmodified epoxy resin (0:1 ratio) in this property. This is probably because the 1:2 ratio cures more rapidly than all the other ratios shown and is typical for all of the commercial epoxy resins. It takes about eight days for the curves to approach a constant rate. This time is probably more than that required for the attainment of dynamic equilibrium and indicates the change in state of cure that the sample undergoes during this period. This change was substantiated by the measurements of other properties such as electrical properties and impact strength with time. (5)

The polysulfide polymer-modified epoxy resin compounds have excellent resistance to most solvents, bases, and water, and to low concentrations of mineral acids. In Table XII, the percent volume swell after thirty days immersion at 80°F is shown for several ratios of liquid polymer to epoxy resin in different solvents and chemicals. These tests were run according to ASTM D471-51T method B. A negative sign indicates shrinkage; the starred entries imply a failure occurred sometime during the test period, such failures being surface blistering, cracking, delamination, or complete disintegration. Cures were carried out at room temperature using 10 parts of DMP-30 per 100 parts of epoxy resin. The immersion tests were started three to five days after room temperature cure. It is felt that the results would have been even better had the samples been allowed to age longer, or if they were post-cured at elevated temperatures prior to testing.

Just as it is important for the potting compound to withstand the corrosive action of various chemicals and solvents, so it is equally important for the potting compound not to exert any corrosive effects on the electronic and other components being potted. The nature of these compounds suggested that there might be some corrosive action on copper and possibly on aluminum. On direct-contact tests with LP-3/epoxy resin compounds as specified by the Bell Telephone Laboratories and on tests with the extraction products of LP-2 compounds as outlined in MIL-S-7502 (USAF), no corrosive action was observed, except where the epoxy resin contained excess chlorine. The direct-contact tests involve helically wrapping two lengths of .0026" diameter Oxygen-Free High Conductivity copper wire (obtainable from Anaconda Wire and Cable Co., New York, N. Y.) around a 9" length of 1"

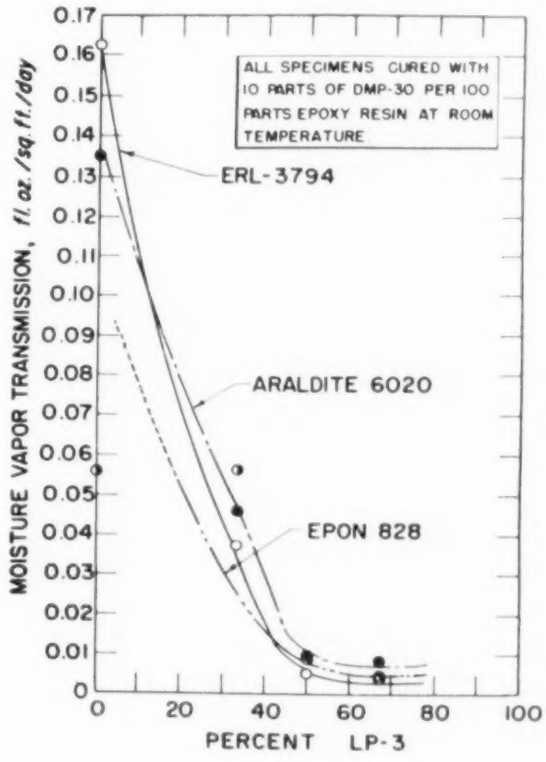
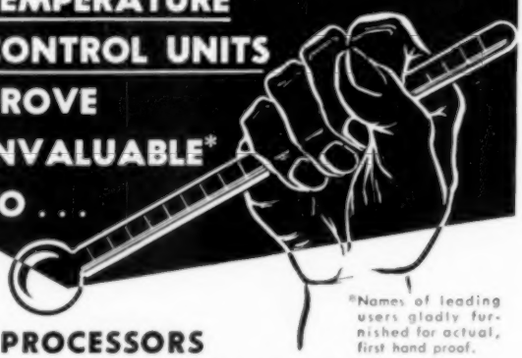


FIG V EFFECT OF LP-3 ON MOISTURE VAPOR TRANSMISSION OF EPOXIES

Sterlco®

TEMPERATURE CONTROL UNITS PROVE INVALUABLE* TO . . .



*Names of leading users gladly furnished for actual, first hand proof.

1. PROCESSORS

Keeps production volume up and costs down to meet ever higher standards at more competitive prices.

2. LABORATORIES

Helps researchers test the real performance of new raw materials for better uses and improved techniques.

3. MATERIAL SUPPLIERS

Test runs under ideal conditions prove the worth of raw materials.

4. EQUIPMENT MANUFACTURERS

Helps a good press do the job it was designed to perform.

Sterlco® ALONE *offers* ALL *these features*

- Fast 9000 watt heating units
- Small total water capacity
- Accurate, fast acting heating and cooling controls
- High velocity circulating pumps
- Ready to go when connected to electricity, water, and drain

Industrial Control Division

STERLING, INC.

3732 N. Holton Street • Milwaukee 12, Wisconsin

Export: Omni Products Corporation, 460 Fourth Ave., New York 16, N. Y.

GET SET and GO with Sterlco®

Model 6003 Dual

Model 6002 Dual

Model 6012 Single

Not shown: Model 6031 Triple Temperature Control Unit

TEMPERATURE CONTROL UNITS

Polysulfide Polymers . . .

O.D. Pyrex glass tubing. The wires are wrapped parallel and are spaced $\frac{3}{8}$ths of an inch apart. One end of each wire is connected to a 45 volt dry cell; the other ends are taped to the glass tube. This places a positive electrical potential on one wire and a negative potential on the other. The wired unit is then coated with the test formulation. A second tube is also coated and then wired after the coating has cured. After connecting the second tube to the battery as described above, the units are mounted on a board and the entire assembly placed in a 95% relative humidity chest at 90°F for a minimum of 15 days. After 4 months under these conditions no corrosion (green color) was observed.

Water extracts of cured LP-3 epoxy resin compounds, using different commercial epoxy resins and both DMP-30 and TET curing agents, show that the curved compounds are essentially neutral with a pH range from 6 to 8 as determined on a Model M Beckman Industrial pH Meter. Approximately ten grams of shavings from the cured sample were soaked for 72 hours in demineralized water and then extracted for 24 hours in a Soxhlet-type apparatus with the original soak water. The pH was determined several times during the test and remained fairly constant before the test was discontinued.

The polysulfide compounds probably have even better resistance to solvents and chemicals than do the modified epoxy resins. Their use in compounds for lining underground gasoline storage tanks is well known. In Table XIII, some solvent swell data are given for an LP-2 formulation after 1 week and 1 year immersion at room temperature, and after 1 year immersion at 158°F and 212°F. The formulation tested was as follows:

LP-2	100
SRF #3	30
Stearic Acid	1
Lead Dioxide	7.5

SRF #3 is a semi-reinforcing furnace black manufactured by the Godfrey L. Cabot Company. The resistance of the polysulfide polymer based compounds to mineral acids is poorer than with the modified epoxy compounds. In the many solvents tested, the maximum swell values were attained in 1 week and remained fairly constant for

Figure 6.

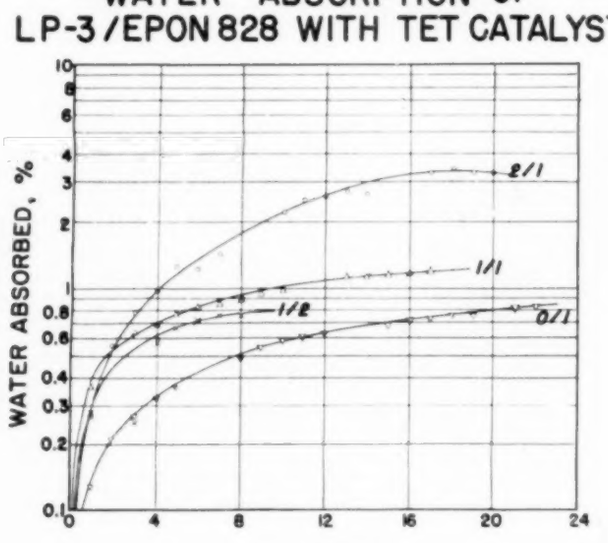


TABLE XIII

Solvent Resistance of a Typical Polysulfide Polymer Based Compound

Test Solution	Percent Volume Swell at			
	Room Temperature		158°F	212°F
	1 Week	1 Year	1 Year	1 Year
SR-10	1	2	—	—
Lubricating Oil	0	5	−19	−39
Diesel Oil 706	0	1	−2	*
SR-6	10	2	—	—
SR-6 + 1% CS Fuel	17	4	—	—
SR-6 + 3% CS Fuel	21	2	—	—
WS 491 Brake Fluid	0	2	−6	*
Benzene	212	238	—	—
Toluene	130	135	—	—
Xylene	50	39	—	—
Kerosene	3	0	—	—
Circo Oil	1	2	−12	*
Linseed Oil	0	7	—	—
Turpentine	4	8	—	—
Ethyl Acetate	41	30	—	—
Acetone	31	8	—	—
Methyl Ethyl Ketone	65	51	—	—
Carbon Tetrachloride	63	33	—	—
Water	3	17	*	*
Denatured Alcohol	4	1	—	—
Isopropyl Alcohol	3	2	—	—
Glycerine	1	6	—	—
Ethylene Glycol	1	11	32	*
Copper Sulfate Solution, 10%	2	8	—	—
Zinc Chloride Solution, 10%	1	3	—	—
Sodium Chloride Solution, 3%	2	3	—	—
Sodium Hydroxide Solution, 10%	1	5	—	—
Glacial Acetic Acid	55	26	—	—
Ammonium Hydroxide Solution, Conc.	3	49	—	—

*sample failed

the ensuing two years in most cases. Some solvents caused progressive swelling over this period. Among these are benzene, water, linseed oil, glycerine, and ammonium hydroxide solution.

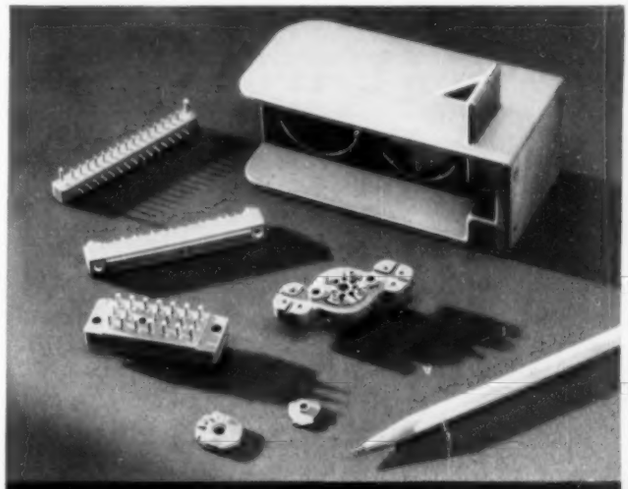
The moisture vapor transmission of an unfilled LP-2 compound cured with 15 parts of C-5 paste on 100 parts of polymer was found to be about 0.0035 fl. oz./sq. ft./day. With 0.3 part of sulfur added, the value becomes 0.0135 fl. oz./sq. ft./day, and with 30 parts of Arochlor 1232 plasticizer (a chlorinated biphenyl manufactured by the Monsanto Chemical Company) the value was 0.0145. All of these values are based on a test specimen thickness of 125 mils interpolated from plots of specimen thickness versus moisture vapor transmission.

The corrosive effects of these compounds on copper and aluminum were also of interest. Tests on copper staining characteristics of LP-2 sealant compounds were conducted. These compounds passed the test for copper corrosion by possible sulfur extracted in 30% aromatic fuels. Similar tests were run on aluminum-surfaced aluminum alloy panels, with the same outcome. In addition, LP-2 sealant compounds have been used against aluminum for years without any indication of direct corrosion or attack by extracted materials. (please turn page)

For **ELECTRICAL SERVICE**

under conditions of

PROLONGED HIGH HUMIDITY



DUREZ 16694

green diallylphthalate

orlon-filled thermosetting

This new orlon-filled granular molding compound exhibits a short-term volume resistivity of 1×10^{16} ohm-cm., and after 720 hours at 100% R.H. at 70°C. it tests as follows:

- Volume resistivity, ohm-cm. . . . . 6×10^{12}
- Surface resistivity, ohms . . . . . 2×10^{12}
- Insulation resistance, ohms . . . . . 1×10^{11}

Combined with its outstanding electrical properties are other characteristics enhancing its importance to electrical design engineers. The material stands up well where machined surfaces are involved. It has excellent resistance to many acids and alkalies, and will not corrode metal inserts. It meets the requirements of MIL-M-18794, Type SDI-5 and molds readily at about 300°F.

DUREZ®

WRITE NOW... for further information including test data on Durez 16694.

Phenolic Plastics that fit the job

DUREZ PLASTICS DIVISION
HOOKER ELECTROCHEMICAL COMPANY
1109 Walck Road, North Tonawanda, N. Y.

HOOKER CHEMICALS PLASTICS

Conclusions

The two types of compounds that have been discussed, namely the polysulfide polymer based compounds which cure at room temperature to tough rubber-like materials, and the polysulfide polymer-modified epoxy resins which also cure at room temperature to plastomers which may be either flexible or solid or have any intermediate properties depending on the ratio of coreactants, have been shown to be outstanding for use as casting resins in potting and encapsulating applications. Their electrical properties limit their use to intermediate electrical requirements. Their unique cure from liquid to solid at room temperature without being dependent on exposure to air, their excellent dimensional stability, ease of handling, protection against mechanical shock, excellent low temperature properties, and unusual resistance to fuels and chemicals are the properties that have found a ready market for these compounds in the casting and embedment field.

Acknowledgement

The authors wish to express their gratitude to the technical staff of the Thiokol Chemical Corporation and to the Technical Service Department in particular, for the assistance which was received in the preparation of this paper.

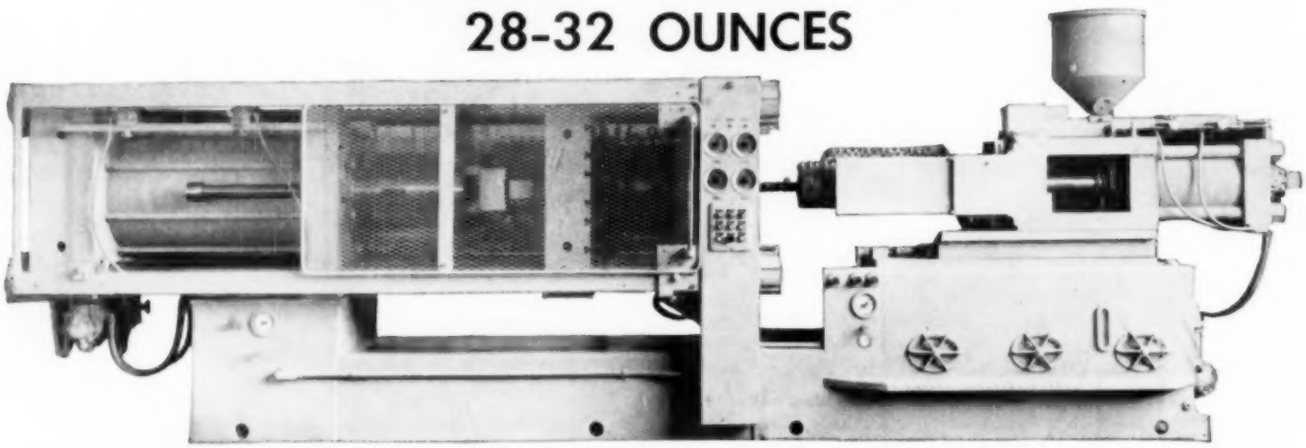
Literature Cited

1. Am. Soc. Testing Materials, Method D648-45T
2. Ibid., D1053-54T.
3. Amstock, J. A., private communication, 1955
4. Charlton, J., Mod. Plast., Sept. 1954
5. Cranker, K. R., and Breslau, A. J., paper presented at the 127th National Meeting of the Amer. Chem. Soc., Cincinnati, April 1955; Ind. Eng. Chem. **47**, 1, 98, (1956)
6. Dummer, W. A., Elec. Mfg., May 1953, p. 84
7. Federal Spec. L-P-406 b, Sept. 27, 1951
8. Fisch, and Hofman, J. Polymer Sci., **12**, 497, (1954)
9. Formo, J., and Bolstad, L., paper presented at the Eleventh Annual Technical Conference of the Soc. of Plast. Engrs., Atlantic City, Jan. 19-21, 1955
10. Formo, J., and Bolstad, L., Mod. Plast., July 1955
11. Government Spec. MIL-c-16923A, Oct. 30, 1952
12. Heitert, T. G., and Niemann, H. W., Elec. Mfg., May 1952, p. 113
13. Javitz, A. E., Ibid., Sept. 1951, p. 103
14. Ibid., April 1955, p. 74
15. Lusby, O. W., private communication, 1955
16. Narracott, E. S., Brit. Plastics, Oct. 1951
17. Patrick, J. C., and Ferguson, H. R. (To Thiokol Corp.) U. S. Patent 2,466,963 (April 12, 1949)
18. Plastics Engineering Handbook, SPI, Reinhold Publishing Company (New York) 1954
19. Shechter, L., and Wynstra, J., paper presented before the 127th National Meeting of the Amer. Chem. Soc., Cincinnati, April 1955, Parts I-III; Ind. Eng. Chem., 47, 1, (1956)
20. Shechter, L. Wynstra, and Kurkjy, R., Ibid.
21. Technical Bulletins, Thiokol Chemical Corp., Trenton, New Jersey

ANNOUNCING THE NEW IMPCO

MODEL HA28-600

28-32 OUNCES



Injection Capacity	28-32 ounces
Injection Pressure	21,200 p.s.i.
Plasticizing Capacity	275 lbs. per hour
Injection Plunger Speed	175" per minute
Clamp Pressure	Adjustable to 600 tons
Clamp Stroke	Adjustable to 30 inches
Machine Cycle	250 per hour
Motor	60 HP — 220/440V — 60C — 3 Ph

SEND FOR BULLETIN P-113
FOR COMPLETE SPECIFICATIONS

IMPROVED
MACHINERY INC.

IMPCO®
NASHUA NEW HAMPSHIRE

SPEaking . . .

(Continued from Page 55)

it necessary to shut down and clean the die.

From a printing or bag making standpoint, flat film is the same as that produced from tubular film. It is most suitable for the large volume runs or those requiring "all around" printing; the printing economies then compensate for the higher set up costs on press and bag machine and for the inherent scrap of the overlap on a back seam bag.

Film characteristics are determined by the operating conditions, for the same resin yields a film with better toughness and transparency at higher compound temperatures and lower water bath temperatures; though the wrinkling tendency and wind-up difficulties increase at lower quench bath temperatures. Improved frictional properties (slip and block) are achieved at lower compound temperatures and higher quench bath temperatures. Cast films are highly transparent though printing may be complicated by a "bellying" tendency after stress relief.

Resin Structure

The properties of the extruded film can be controlled to a large extent by proper resin selection based upon the following general guides:

a) Stiffness and brittleness increase with density.
b) Strength increases and brittleness decreases with narrower molecular weight distribution.
c) Flow and draw properties improve with higher melt index, but strength and coefficient of friction become worse.

For example, a resin with a 2.1 M.I., 0.923 density and a 13 M.W.D. would yield a good, tough clear film by tubular extrusion suitable for either produce or soft goods applications. The same resin extruded out of a flat die would yield a film suitable for soft goods but with insufficient toughness for produce; decreasing the M.W.D. to 7, would yield a film with sufficient toughness for both applications.

The addition of slip additives to the resins has complicated all manufacturing phases, but the primary difficulty is observed in treating where presence of the slip agents make more rigorous treatment necessary. The time interval between extrusion and treatment should be constant and at a minimum to avoid additional variables. Flame treating provides potentially a more rigorous method at speeds of 500 FPM but introduces difficulties in blocking of tubing and impairment of sealability. Electrical discharge methods do not impair sealability as much as flame treating, but are critical to control, have lower optimum speeds (100-150 FPM), and may treat completely through the film in the event of wrinkles or wide gauge variation.

Molders confirm press-makers' tests;

WEST temperature controls chosen for BAKER plastic presses

Baker Brothers, Inc. of Toledo make a full line of presses, from 25 to 450 ton capacity. They handle *any* type of thermo-setting material . . . adjust as to time and length of function . . . operate automatically, manually or combination.

Baker Brothers test everything that goes into making their presses. They found best results with West temperature controllers. And, increasingly, their customers *specified* West. Now, subject to custom requirements, West is standard on any Baker presses which include instruments.

YOU stand to gain by finding out why *every year more engineers specify WEST instruments* . . . why more than half of *all* new installations are by WEST. Call any West office or write for *facts*.

the trend is to **WEST**

WEST Instrument CORPORATION
SALES OFFICES IN PRINCIPAL CITIES
4359B W. MONTROSE, CHICAGO 41, ILL.
British Plant: WEST INSTRUMENT LTD.
52 Regent St., Brighton 1, Sussex
Represented in Canada by Upton, Bradeen & James

CLASSIFIED ADS

Chemical Engineer

Eastern, medium-size progressive plastic company has excellent opening for aggressive young man. Must be capable of growth with the organization. Should have had at least two years experience in pilot plant set-up or in process research and development. Give complete resume of education, experience and salary requirements. All replies kept strictly confidential. Reply Box No. 2556. SPE JOURNAL, 34 East Putnam Avenue, Greenwich, Conn.

Mechanical Engineer

Medium-size progressive, eastern plastic manufacturer has excellent opening for aggressive young man to be in charge of Fabrication Department (Nylon and Teflon products). We require at least three years production experience in similar activity. This is a real opportunity for a top-notch individual who desires to grow with our expanding organization. Give full details regarding education, experience and salary requirements. All replies kept strictly confidential. Reply Box 2656, SPE JOURNAL, 34 East Putnam Avenue, Greenwich, Conn.

For Sale

3,000# Hex Mixer, Two compartments—1,500# capacity each. Driven with 5 HP motor with built-in magnetic Brake. Handy handler conveyor for easy loading. Excellent for mixing and blending plastic materials. Easy to clean. Best offer. Moslo Machinery Company, 2443 Prospect Avenue, Cleveland 15, Ohio.

Foreman—Mold Shop

Custom mold shop specializing in the building of steel injection and compression molds for molding of plastics requires Foreman with all around mold building background. This is one of the nation's largest mold shops, located in the mid-West. High hourly rate and many fringe benefits. Applicant must be willing to relocate if necessary. Reply Box Number 2956, SPE JOURNAL, 34 E. Putnam Avenue, Greenwich, Connecticut.

Injection Molding Machinery Manufacturer has openings for Sales Engineers and/or Manufacturer's Representatives and Service Men in many areas: West Coast, Dallas, St. Louis, St. Paul, Detroit, all the South and many others. Give complete resume of experience and background. Must have experience in plastics field. Write Box #2856, SPE JOURNAL, 34 Putnam Avenue, Greenwich, Connecticut.

Position Open

Physicist, electrical engineer or physical chemist as Research Associate in Plastics Laboratory for dielectric studies in polymers, to head small group and teach course. Write to L. F. Rahm; Princeton University.

Chief Engineer Wanted

Graduate Engineer, preferably chemical, with 7 to 10 years' experience in plastics industry, primarily in extrusion field although molding experience also desirable. Thorough understanding of thermoplastic and thermosetting materials and the equipment and processes by which these are fabricated. Responsibilities will include die design, production methods, selection of equipment, experimental and development programs for perfection of new products. Will report directly to top management. Location Connecticut. Reply Box 3056, SPE JOURNAL, 34 E. Putnam Ave., Greenwich, Conn.

Plastics Engineer

DECISION / INC, Management and Recruitment Consultants, knows of an outstanding position for a young graduate Chemist or Chemical Engineer in the Plastics field. Past experience of 3-4 years should include design of small plastic parts, plastic testing and specification, injection molding, part-molding processing, and compression molding. This is a responsible position for a young Engineer or Scientist interested in development testing program. Nationally known manufacturer offers unique employee benefits. Address resume, including salary requirements in strict confidence, to Box 1776, SPE JOURNAL, 34 E. Putnam Ave., Greenwich, Connecticut.

Position Wanted

Plastics engineer, with experience in injection, compression and transfer molding. Materials thermosetting and thermoplastic, estimating, product design, production engineer, technical sales service, mold design, procurement, estimating and expediting. 15 years experience in the industry. Reply box 2756, SPE JOURNAL, 34 E. Putnam Ave., Greenwich, Conn.

Advertisers' Index

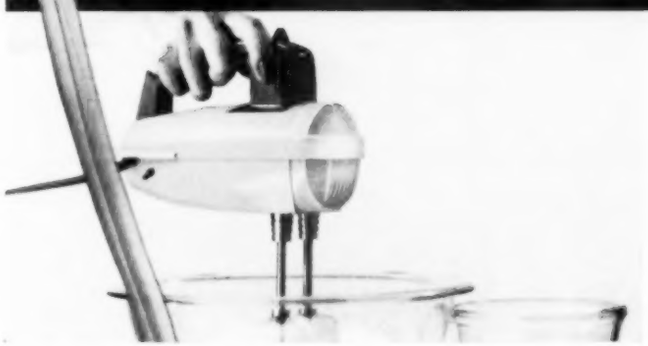
Acheson Dispersed Pigments Co. 7
Allied Chemical & Dye Corp., Barrett Div. 32-33
Allied Chemical & Dye Corp., National Aniline Div. 11
Allied Chemical & Dye Corp., National Aniline Div. 17
American Cyanamid Co. 65
Barrett Division, Allied Chemical & Dye Corp. 32-33
Celanese Corp. of America, Plastics Div. 2-3
Detroit Mold Engineering Co. 14
Dow Chemical Co. 18
Drycol Div., Gering Products, Inc. 55
Durez Plastics Div., Hooker Electrochemical Co. 61
E. I. duPont de Nemours and Co., Inc. 9
Frank W. Egan and Co. 16
Enjay Co., Inc. 46
Escambia Bay Chemical Corp. 12
General Dyestuff Co. 57
Gering Products, Inc., Drycol Div. 55
Hercules Powder Co. 66
Hooker Electrochemical Co., Durez Plastics Div. 61
Hydraulic Press Mfg. Co. 15
Improved Machinery Co. 62
M. W. Kellogg Co. 45
Koppers Co., Inc. 10
Manco Products, Inc. 56
Monsanto Chemical Co. 6
National Aniline Div., Allied Chemical & Dye Corp. 11
National Aniline Div., Allied Chemical & Dye Corp. 17
National Distillers Products Corp., U. S. Industrial Chemicals Div. 4
Newark Die Co. 8
Package Machinery Co.; Reed-Prentice Corp. 13
Reed-Prentice; Affiliate of Package Machinery Co. 13
Sterling, Inc. 60
U. S. Industrial Chemicals Co., Division of National Distillers Products Corp. 4
West Instrument Corp. 63

If it's used in the home

make it beautiful
make it safe
make it durable

with Cyanamid plastics and resins

FOR THE MODERN DECORATOR LOOK in wiring devices—and for safety's sake—it's BEETLE® urea molding compound in light, cheerful ivory. BEETLE molds well, is sturdy, hard, and resists heat and discoloration. If it carries current, make it safe, make it attractive, make it BEETLE.



FORM AND FINISH ARE ONE in this two-tone Iona hand-mixer housing made of CYMEL* melamine molding compound. This bypasses expensive finishing steps. The "all-through" color cannot chip, wear off or stain. CYMEL resists bumps and scratches and the heat of the motor. Light in the hand, hard to harm, easy on the eyes—that's CYMEL.

COLOR COMES TO STAY in the modern kitchen, when you use a CYMEL melamine resin baked coating. Gleaming beauty becomes a well-nigh inseparable part of range, refrigerator and washer. The hard, glossy coating stands up to spattering grease, heat, soaps and detergents . . . resists discoloration. It cures with lightning speed—and lasts and lasts and lasts.

*Trademark

Pick and choose among melamine, urea and methylstyrene molding compounds . . . polyester resins . . . resin adhesives . . . resins for surface coatings. Cyanamid chemistry makes them *your model materials!*

IN CANADA: North American Cyanamid Limited, Toronto and Montreal

OFFICES IN: Boston · Charlotte · Chicago · Cincinnati · Cleveland · Dallas · Detroit · Los Angeles · New York · Oakland · Philadelphia · St. Louis · Seattle

CYANAMID

AMERICAN CYANAMID COMPANY
PLASTICS AND RESINS DIVISION
32D Rockefeller Plaza, New York 20, N. Y

hi-fax for better housewares

Hi-fax, the new ethylene polymer to be made by the Hercules process, brings a new range of exciting properties to housewares. A completely new plastic, Hi-fax offers a combination of unique properties never before available.

Here's what Hi-fax brings to housewares:

Hi-fax can be sterilized! Products made with Hi-fax can be immersed in boiling water without distortion.

Hi-fax is four times as rigid! Provides four to five times the rigidity of regular polyethylene.

Hi-fax is twice as strong! Has double the strength of conventional polyethylene.

Hi-fax has improved resistance to solvents and greases! Has a fluid permeability of only ⅓ that of regular polyethylene.

All this plus: a richly colorful, lustrous finish. Easy to mold or fabricate by conventional methods.

That's why: People who have seen Hi-fax agree it's the plastic of tomorrow for tomorrow's superior products. Whether you make or design toys, housewares, industrial moldings, sheet and film, pipe, bottles, or electrical insulation, you'll want to learn more about how Hi-fax can improve existing products or help launch new ones.

Cellulose Products Department

HERCULES POWDER COMPANY
INCORPORATED

930 King St., Wilmington 99, Del.

HERCULES

HI-LITE ON

hercocel®

Hercocel — Hercules cellulose acetate — another member of the growing Hercules plastics family, keeps products on the move in design, production, and sales. The General Electric Portable Mixer is typical of the products that take advantage of this versatile material. Its flame-resistant housing, beautifully styled for the modern kitchen, is lightweight but strong, chip proof and stain-resistant — an example of the many products today that rely on economical, easy-to-mold Hercocel.